STACK
ANNEX
5
048
595

A 000 026 753 4
UC SOUTHERN REGIONAL LIBRARY FACILITY

3.10

OBSERVATIONS

UPON THE

NATURE AND PROPERTIES

OF THE

ATMOSPHERE:

DESCRIBING

The Effects of HEAT and COLD in it.
The THEORY and CAUSE of WINDS.
The RISE and FALL of VAPOUR.
The CAUSE of SQUALLS, TORNADOES, and HURRICANES, and of the VARIETIES of WEATHER.

TO WHICH ARE ADDED,

OBSERVATIONS,

ON THE

MOON's INFLUENCE UPON THE ATMOSPHERE,

AND THE

RISE AND FALL OF THE MERCURY

IN THE

BAROMETRICAL TUBE.

By MURDO DOWNIE,
A Maſter in the Royal Navy, and Author of the "Marine Survey of the Eaſt Coaſt of Scotland."

Aberdeen:
Printed by J. Chalmers & Co.
SOLD BY D. STEEL, UNION-ROW, TOWERHILL, LONDON: W. REID,
LEITH: BY THE BOOKSELLERS IN ABERDEEN: AND
BY THE AUTHOR THERE.

1801.

Entered in Stationers Hall, agreeable to Act of Parliament.

INTRODUCTION.

THE Atmoſphere affords an ample and extenſive field for the reſearches and contemplation of the Philoſopher; and altho' many important and intereſting diſcoveries have already been made in it, yet a great, perhaps the far greater part of this field, remains unexplored, and hid from human knowledge; and notwithſtanding farther diſcoveries may be yet made, it is very probable, from its extent, and the extreme ſubtilty of the ſeveral parts of which the Atmoſphere is compoſed, and from our confined ſituation and limited underſtandings, that it may remain ſo to the end of the world.

But altho' we can never attain to a perfect knowledge of the ſubſtance and properties of the Atmoſphere, yet from what is already known by obſervation and experiments, many of the appearances of wind and weather that are daily exhibited near the ſurface of the earth may be rationally accounted for: and as the principal part of the affairs in life are deeply intereſted in the winds and weather, it naturally follows, that every diſcovery which tends to a knowledge of their primitive cauſes, and how they operate in producing the ſeaſons, in different countries, ſituations, and climates, with the connection and effects the ſeaſons in each climate may have upon the reſt—ſo that from a knowledge of the ſeaſons in one or more climates, a judgment may be formed of that in another; or what is of ſtill greater conſequence, that from a knowledge of a number of bygone ſeaſons, an eſtimate may be formed how a future may turn out, together with every thing that may tend to throw any light upon the ſeeming uncertainty of the winds and weather—muſt certainly be of the moſt eſſential ſervice to mankind.

From 30 year's experience in cruizing and traverſing in different directions both ſides of the Atlantic ocean and its adjoining ſeas,

1288491

the author has made (he hopes) a ſucceſsful attempt, in the following ſheets, to prove, from the effects of heat and cold, the theory and cauſe of winds; that there is a regular circulation of the Atmoſphere over that ocean, and the Continents of Europe, Africa, and America bordering it; from which ariſe the cauſes of the different ſorts of weather found in each part; which when farther eſtabliſhed by future obſervations and diſcoveries, may lead to the important and uſeful diſcovery, how the huſbandman, from the direction of the clouds, appearance of the ſky, and denſity of the Atmoſphere, by means of the Barometer, compared with the preceding weather and appearances in his own and other countries, may according to the ſeaſon chooſe the moſt proper time for depoſiting his ſeed, reaping his harveſt, together with the other operations of huſbandry; and the navigator, by the ſame means, may purſue the tract in croſſing the ocean in which he is leaſt liable to obſtruction from, and in which he will be moſt aſſiſted by, the prevailing winds.

In the proſecution of this ſubject it will be found, that all the concluſions are agreeable to the theory of gravity, the laws of motion, and the properties of fluids, as far as they are known, together with the reſult of known experiments and undoubted obſervations; except when ſuppoſititious theories concerning the electric fluid are introduced, which was abſolutely neceſſary for reconciling appearances and connecting events: for it is now univerſally allowed, that the electric fluid forms a conſiderable part of the Atmoſphere, and is an active agent in many, if not in moſt of the operations that take place there, altho' from its extreme ſubtilty it is not yet ſufficiently known in what manner it acts. Theſe ſuppoſititious theories are reſorted to as ſeldom as poſſible; but where they happen to occur, they will be found to be ſuch as are the moſt probable from exiſting circumſtances, and may remain as ſuppoſititious, without any detriment to the general theory, until they are confirmed by obſervations, or ſuperſeded by ſome other quality producing the ſame effect.—So that altho' the general theory laid down here, from this as well as other circumſtances, cannot be ſuppoſed to be perfect in all its parts, yet by being eſtabliſhed upon a ſure foundation, it will be capable of receiving continual improvement from future obſervations and diſcoveries.

As little is ſaid concerning the electric fluid in the proſecution of the following ſubject, it may not be amiſs to make ſome obſervations concerning it here, in the doing of which I ſhall begin with that extraordinary phœnomenon the Waterſpout, the cauſe of which has hitherto been ſo little known.

Various are the theories that have been advanced concerning the cauſe and formation of Waterſpouts, the merits of which it is not intended to diſcuſs here; only it is agreed by all, that the Waterſpout is an electric phœnomenon, and it would ſeem, among many, that the principal reaſon for this opinion is, becauſe ſuch a phœnomenon, whoſe appearance is ſo repugnant to all the laws we know in nature, cannot be accounted for any other way. Waterſpouts always appear in warm weather, generally in calms or with little wind, and their upper end is always connected with a large denſe cloud. The following is the deſcription of one obſerved upon the coaſt of North America; and its happening during a freſh gale makes it more ſingular.

Upon the forenoon of the 9th of October, 1795, while cruizing in His Majeſty's ſhip Reſolution of 74 guns, (then bearing the flag of the late Admiral Murray) in company with H.M.S. Africa of 64 guns, commanded by the late Admiral, then Captain Home, in latitude 32, and longitude 66½ W. having the wind at N. N. E. blowing a freſh gale, and the ſhip ſteering by the wind eaſt for the iſland of Bermuda, we were ſurpriſed with a Waterſpout formed in an inſtant, directly to leeward, at about two miles or little more diſtant. Both the Africa and us fired ſeveral 18-pound ſhot at it, which fell a little ſhort; and altho' ſome of the ſhot fell very near, yet they had no viſible effect upon it. Its appearance was that of a long ſlender pillar, with the upper end ſpreading into a large denſe cloud, of which it ſeemed to form a part, and the lower end reached to within about 20 or 30 feet of the ſea, where it was obſcured from the ſight by the water being violently thrown up and agitated, ſo as to reſemble a number of fountains or water engines playing perpendicularly round the lower end of the ſpout. The pillar became more tranſparent in proportion as it decreaſed in ſize from the cloud downward, until at the lower end, where it was near perfectly ſo; and a ſmall column, of an equal diameter and more tranſparent than the reſt, appeared up thro' the middle, ſo that about the lower end it reſembled an empty glaſs tube in appearance; from thence the tranſparent column in the middle became gradually obſcured, the higher up, by the opacity of the outſide, until it altogether diſappeared near the cloud. The ſpout appeared at its full ſize, or nearly ſo, when firſt ſeen, and began to decreaſe ſhortly after, and turning gradually ſmaller, it in a ſhort time vaniſhed in a ſlight ſhower.—We were too intent gazing at this extraordinary phœnomenon to mark the exact time it laſted, but ſuppoſed it to continue 10 or 15 minutes, and its diſtance from the ſhip was pretty accurately aſcertained by the ſhot fired at it nearly reaching; but what appeared moſt remarkable was, that altho' the wind blew ſo ſtrong a gale, that the ſhip could only carry reefed topſails, (from which the velocity of the wind cannot be eſtimated at leſs than 30 or 40 miles an hour) yet the Waterſpout ſeemed to move but very little from the place where it was firſt ſeen. The ſhip was going at the rate of 5½ miles an hour, and increaſing her diſtance from the ſpout, yet after continuing the above-mentioned time, it was conſiderably within the verge of the viſible horizon as ſeen from the quarter-deck, when it vaniſhed, (as upon the quarter-deck the eye was elevated 23 feet above the ſurface of the ſea, the horizon would therefore be ſeen about 6 miles diſtant): now allowing the ſhip to have increaſed her diſtance from the ſpout half a mile during its continuance, and that it vaniſhed a mile within the verge of the viſible horizon, which, together with 2 miles it was diſtant when firſt ſeen, will make in all 3½ miles, which taken from 6 miles (the diſtance of the viſible horizon) leaves 2½ miles for the ſpout to move in 10 minutes; where as the wind muſt have gone at leaſt 5 miles in that time, and conſequently 2½ miles faſter than the Waterſpout. Indeed it is very probable the Waterſpout did not move ſo much, in proportion to the wind, as the above calculation gives the leaſt difference between their motions that could have been allowed from the obſervations: the intention of this calculation being principally to prove that the Waterſpout in ſome meaſure reſiſted the force of the wind. I have been thus particular in the deſcription of a Waterſpout, in order that thoſe who have never ſeen one may form a juſt idea concerning it; and ſhall now proceed to give an opinion as to the moſt probable cauſes that operate in its production.

It is evident from reaſon, and the common operations of nature, as well as from the teſtimony of thoſe who (without being prejudiced by fabulous ſtories concerning them) may have ſeen Waterſpouts ſo near as to obſerve them minutely, that they are nothing elſe than the common operations of a cloud condenſing into water and falling to the earth; only inſtead of falling in drops and forming a ſhower of rain, the drops by joining coaleſce and form a ſtream, which deſcending with great velocity, continues until the denſeſt part of the cloud being diſcharged, it is exhauſted, and becomes too thin and expanded for the drops any longer to coaleſce. The ſtream then ceaſes, and the deſcent of the water is converted into a ſhower.

It is univerſally allowed, from the reſult of numerous experiments, that a greater quantity of electric fluid is always found in a cloud than in the other adjoining parts of the Atmoſphere; and it commonly happens, that the denſer the cloud is, the more electric fluid is contained in it; from which circumſtance I have, in the following treatiſe, taken the liberty of ſuppoſing, that the electric fluid, by attaching itſelf to the particles or rather globules of water, by ſurrounding them in form of an Atmoſphere, contributes by its levity towards ſupporting them afloat in the Atmoſphere; while at the ſame time, by thus ſurrounding them, it forms that repelling property, which when gathered into a cloud, by their gravitations hinders them from uniting in a maſs. Now whether theſe globules are hollow, by which the fluid incloſed as well as that ſurrounding them helps to buoy them up, or whether they are compact, is a circumſtance not yet diſcovered; but in either caſe, whatever form or ſize they may be of, it is evident, that when from any circumſtance two or more of theſe globules join and form a drop, the electric fluid attached to each will now ſurround the whole drop, whoſe ſurface being leſs than the ſurfaces of the ſeparate globules which formed it, and the electric fluid reaching to only the ſame diſtance from that ſurface, there will be more fluid than will attach to it; therefore the remaining part will inveſt any of the other globules which may have a leſs proportion of fluid ſurrounding them, while at the ſame time the great body of electric fluid in the cloud, by inveſting it, continues to communicate and adhere together.— From theſe circumſtances, when there happens to be a very denſe cloud containing an extraordinary quantity of electric fluid, and of great perpendicular dimenſions, ready to condenſe into water; if this condenſion firſt takes place in the middle of the cloud, the electric fluid will be forced to the outſide by the coaleſcing of the drops, where by collecting the ſmaller globules of water or vapour, and inveſting them, will by this means become of more conſiſtency; and thus by collecting in great abundance, and adhering together, will inveſt the cloud all round, when at laſt the water collected by condenſation will by its weight break thro' the under part, and falling, carry down part of the electric fluid which may be attached to it. Thus the electric fluid being preſſed down by the weight of the cloud, and it again preſſing up by its levity, will, with the thinner vapour attached to it, form a kind of funnel for collecting the drops as they deſcend, of which the part attached to the deſcending water forms the ſpout; and thus the operation will continue until the denſeſt part of the cloud is diſcharged in the ſtream, which forms the tranſparent centre of the pillar, having the electric fluid, mixed with innumerable particles of water, of the nature and conſiſtency of vapour, forming the outſide. This ſtream falling from ſo great a heighth, acquires a very great degree of velocity, with which it ſtrikes the ſurface of the ſea with ſuch force, as from the recoil to cauſe that violent ebullition or flying up of the water, that is always ſeen round the lower end of the ſpout.

The beginning of a Waterſpout is almoſt inſtantaneous, and is never perceived unleſs the eye ſhould chance to be directed to the ſpot at the time, but its termination is gradual. It only exhauſts the denſeſt part of the cloud, ceaſing when the ſupply of water becomes too little for continuing the conſtant ſtream. By eſtimating the height from which a Waterſpout deſcends at an Engliſh mile, its velocity when ſtriking the ſurface of the ſea, will be at leaſt 560 feet per ſecond, which upon ſtriking a ſhip muſt render it very dangerous, if not fatal, and as ſuch is much to be dreaded. This body of water deſcending with ſuch velocity, accounts for its reſiſting the force of the wind, when its motion exceeds that of the cloud from which the water deſcends. The common ſtory of the firing of a gun breaking the Waterſpout is erroneous; even a ſhot falling near it has no effect that way. What effect it would have upon ſtriking it, I cannot tell, having never ſeen it take place; and altho' after converſing upon the ſubject with ſeveral intelligent ſeamen, I have not met with one who ſaw a ſhot deſtroy a Waterſpout. Indeed I will not pretend to ſay what effect an iron ball paſſing thro' the electric fluid that circumſcribes the ſpout, may have upon it; only of this I am pretty certain, that many of the vulgar ſtories propagated concerning Waterſpouts are fabulous.

I have always obſerved, that Waterſpouts, lightning, and other electrical phœnomena, are far leſs frequent toward the middle of the ocean, than they are upon the land, or near it; and when they happen upon the ſea, the cloud that contains them is generally obſerved to have come from off the land; for which reaſon we find, that electrical phœnomena are more frequent, and are found to reach to a greater diſtance, upon the ſea bordering the Eaſt coaſt of N. America, than upon that bordering the Weſt coaſt of Europe, becauſe of the prevailing weſterly winds carrying the clouds charged with electric fluid off the land upon the ſea near the American coaſt, whereas upon the European coaſt theſe winds confine the clouds upon the land. It is alſo a known fact, that within the limits of the N. E. trade-winds, and half way between the Cape Verd and Windward Weſt India Iſlands, more eſpecially in the latitude of theſe iſlands, that ſcarce any of theſe electrical appearances ever happen, whereas upon the ſhores of Africa and America, in the ſame climate, they frequently rage with great fury. Indeed lightning is ſeldom found violent near the middle of the ocean in any part, and Waterſpouts never happen there; from all which it appears evident, that the electric fluid is more abundant, or at any rate exerts itſelf more upon the land than it does upon the ſea. Altho' lightning is almoſt always accompanied with a cloud, yet during cold weather in northern climates, it is ſometimes ſeen without a cloud; but then it produces no noiſe.

From the extreme ſubtilty of the electric fluid, little is known concerning it, except its appearanee and effects. In appearance it is every way ſimilar to fire, and its effects are ſuch as in general would be produced by that element; conſequently if the electric fluid be not the ſame as the fluid of fire, it cannot differ much from it; for from late experiments, fire is allowed to be a fluid inherent in all matter, and a great if not the moſt part to exiſt in ſubſtances in a latent ſtate, and the electric fluid may be alſo ſaid to be the ſame. Fire is collected and becomes active, or in a burning ſtate, by friction; the electric fluid by friction is found to do the ſame, by accumulating about theſe ſubſtances to which it has a propenſity to adhere, and which, from that circumſtance, are commonly called electrics; and it is from its effects produced from theſe accumulations, that its exiſtence comes to our knowledge. And may not the production of fire by friction, in ſubſtances which are not electrics, be the electric fluid collected, and activity given to it, ſo as to become fire in a burning ſtate, altho' by being non-electrics, the fluid does not adhere in a latent ſtate, ſo as to accumulate? So that the effects of the electric fluid, and of fire, being the ſame, as far as our knowledge goes in tracing them, there is every reaſon to ſuppoſe that they are actually of one and the ſame quality.

Now by admitting (as we are led to believe by modern diſcoveries) that a fluid in the act of freezing emits a quantity of fire, and imbibes a like quantity in the act of thawing, and that the electric fluid and the fluid of fire are the ſame; may we not carry our conjectures ſomewhat farther, by ſuppoſing that the fire emitted from the nightly freezings that take place in the climates near the poles during the winter ſeaſon, being, either from the activity of the froſt, or from there being no water floating in the air to attach itſelf to, driven into the higher regions, where accumulating from frequent freezings, it gathers activity from its quantity, upon the ſame principle that lightning is produced in a cloud, and thus appearing in fire, forms what is commonly called the Aurora Borealis.—What farther countenances this ſuppoſition is, that as freezing takes place more frequent, and by increaſing becomes more general, in the end of autumn and beginning of winter, ſo we find the Aurora Borealis to be more abundant in this ſeaſon than at any other time of the year. Alſo, upon account of more freezing taking place upon the continents, we ſee it more abundant there than upon the ſea; and ſince it is generally ſuppoſed that there is ſome connection between the electric and magnetic fluids, may not the revolution of the magnetic pole round the pole of the earth have ſome connection with a periodical return of the Aurora Borealis?

As the accumulation of the electric fluid, in the apparatus of an electrical machine, is found to be drawn from the neareſt ſolid ſubſtances of whatever kind, with which it communicates, it may be readily ſuppoſed, that it in ſome degree adheres univerſally to all ſubſtances; therefore as ſuch, may it not be ſuppoſed to form that repelling force or quality, which by reaching to an extreme ſmall diſtance from the ſurface, commonly hinders the ſmaller parts of matter from uniting, ſuch as the cauſe why a drop of water or other fluid, which we plainly ſee will not of itſelf ſpread along a dry plain, and two drops, though placed ever ſo near each other, yet they will not unite until they be made to touch: and that it is ſome principle which hinders them from uniting, is plain from their readily uniting and running together, forming one drop, the inſtant this principle is removed by their touching: now it is plain, that this repelling principle lies only on the ſurface of ſubſtances, becauſe it is more conſpicuous in the ſmall parts of matter than in the great, which muſt be owing to the greater proportional ſurface in the former; for, a very ſmall needle, well rubbed and dry, we are told, will float upon the ſurface of water, notwithſtanding the great difference in ſpecific gravity; and this floating of the needle may be evidently ſeen to be caused by an Atmoſphere, as above ſuggeſted, (or of ſome ſuch property) ſurrounding it, which, by repelling the water to a certain diſtance, diſplaces ſo much of it as to exceed the ſpecific gravity of the needle; whereas a piece of ſteel of the ſame quality, either larger or of a more compact form, will immediately ſink, becauſe its ſurface being ſo much leſs than that of the needle in proportion to the quantity of matter in each, and the repelling quality reaching only to the ſame diſtance in each, the quantity of water diſplaced by it in the larger ſubſtance, will be too ſmall to make up the difference in ſpecific gravity.

It is found, that heat increaſes this repelling quality as above deſcribed, and that the heat generated by rubbing increaſes it more than that communicated any other way; which evidently amounts to a preſumptive proof of its being an electric property; and it is from the above conſiderations, that, in diſcuſſing the following ſubject, I have adopted the theory, that the electric fluid by forming an Atmoſphere round each of the particles, or ſmall globules of water, that compoſe a cloud, is the repelling property which hinders them from uniting together in one maſs. This electric Atmoſphere alſo preſerves them from the influence of the froſt, ſo that theſe globules of water may be frequently ſeen floating in a fluid ſtate, in a cold below freezing; but then the moment they touch any thing by which the electric Atmoſpere is broke, they inſtantly freeze; and from the ſame cauſe water lying perfectly ſtill and undiſturbed, is found to reſiſt the froſt for a conſiderable time; but the inſtant the electric Atmoſphere upon its ſurface is broke by diſturbing it, the froſt takes effect. And may it not be from the electric fluid adhering to, and being carried away by the ſteam continually riſing from the ſurface of heated water, that in cooling, the froſt ſo ſoon takes effect upon it?

OBSERVATIONS

UPON THE

NATURE AND PROPERTIES

OF THE

ATMOSPHERE.

THE compoſition and properties of the Atmoſphere, with the various appearances that are exhibited in it, are ſubjects that have engaged the attention of Philoſophers in all ages; and many are the ſuppoſitions and theories that have been advanced concerning them, which from their variety, and the inſuperable difficulty (becauſe of their extreme ſubtilty) of aſcertaining their eſſences and properties by experiment, plainly diſcover the full attainment of this ſubject to lie as yet beyond the reach of human knowledge. However, late years have thrown a conſiderable degree of light upon this intricate ſubject, from a number of experiments made by various perſons, from which it is found that the Atmoſphere contains (beſides elementary air) particles of every ſubſtance we know in nature, and probably of ſubſtances we know little or nothing about, and that even elementary air is found to be of various kinds or qualities, and to be produced from ſolid ſubſtances of almoſt every ſort by their decompoſition; from which it appears, that this air muſt form ſome part or property in theſe ſubſtances while in their ſolid ſtate, and as ſuch may be then conſidered as part of them; ſo that it is only when let looſe and floating by its elaſticity, that with propriety it can be called air.

From theſe circumſtances, and from the yielding property of its parts, the Atmoſphere is found to be a ſubtle fluid, conſiſting of an heterogeneous maſs of various ſubſtances, endued with an aſtoniſhing elaſticity, from which it is capable of a degree of compreſſion beyond what we know, and of an expanſion proportionate to that, which is ſo great, that if the weight of the incumbent Atmoſphere was taken from off any ſmall quantity of it, this ſmall quantity would diffuſe itſelf ſo as to occupy a ſpace almoſt infinite to what it did before; therefore, on account of this elaſtic quality, that part which lies neareſt the ſurface of the earth muſt be the denſeſt, by the compreſſion it receives from the weight of the upper parts lying upon it; conſequently the higher the leſs muſt be its denſity, becauſe of the leſs quantity and incumbent weight; from which it appears, that as the weight or preſſure is leſs, ſo from its elaſticity the greater will be the expanſion and the ſpace it occupies; in ſo much, that in the upper part of the Atmoſphere, its expanſion and the ſpace occupied by it will be almoſt unbounded.

From this elaſtic quality of the Atmoſphere it will be evident, that where half the preſſure is removed, the expanſion and ſpace occupied by it will be double, which proportion of expanſion to the decreaſe of preſſure holds good, with but little variation, from the ſurface of the earth upwards; ſo that the middle line, where half the preſſure of the whole Atmoſphere takes place, muſt be but a ſmall proportional part of its whole height above the ſurface of the earth; accordingly, the experiments that have been made for aſcertaining this line, places it at nearly 3½ Engliſh miles above the level of the ſea; ſo that one half of the Atmoſphere lies below this line of heighth, and the other half above it. therefore as the denſity of the Atmoſphere at 3½ miles perpendicular height is decreaſed one half, it will be only one fourth at 7 miles, one eighth at 10½ miles, and one ſixteenth at 14 miles, and ſo on, the denſity decreaſing in a geometrical proportion as the altitude increaſes in an arithmetical one.

The elaſticity of the Atmoſphere is conſiderably increaſed by heat, and in the ſame proportion diminiſhed by cold, and although the elaſticity be great in the whole, yet each ſubſtance and air that compoſe the Atmoſphere is poſſeſſed of it in a different degree, ſome of them being much more elaſtic than others; alſo heat increaſes the elaſticity of ſome ſubſtances a conſiderable degree more than it does that of others.

Since heat has the property of expanding the Atmoſphere, it hence follows, that where an extraordinary degree of it happens, the Atmoſphere in that place by being expanded or rarified by it, will occupy more ſpace, and conſequently become of leſs weight or ſpecific gravity, by which means the heavier Atmoſphere near it will be put in motion by its ſuperior weight, and ruſh toward the lighter in order to reſtore the equilibrium; and from a well known general law in nature, that a body in motion perſeveres in that ſtate until from ſome outward influence it is led to change it, this ruſhing in of the denſe Atmoſphere will not ceaſe when the equilibrium is obtained, but continue until its force is overcome by the weight of an accumulation. This ruſhing of heavier Atmoſphere toward the lighter, with every other motion in it, from whatever cauſe, is what we commonly call wind—the cauſes, circulations, and properties of which, is the ſubject of the following enquiry.

As the expanſion by heat is different in different ſubſtances, a greater expanſion muſt neceſſarily take place where theſe ſubſtances predominate that are moſt ſuſceptible of it, cauſing there a greater difference in denſity by the ſame degree of heat than otherwiſe would be from ſubſtances of leſs expanſion, producing thereby a quicker motion in the ruſhing in of the denſer Atmoſphere to reſtore the equilibrium, and thus, where this happens, make a difference in the ſtrength of the wind. But as the difference of expanſion from heat, with reſpect to different ſubſtances, bears but a very ſmall proportion to the general expanſion of the whole, and as they are never found ſeparate, but always blended together in the Atmoſphere, and as theſe ſubſtances (water excepted) which ſeparately compoſe the Atmoſphere (from their ſubtilty, and being ſo intimately mixed) are but imperfectly known; I ſhall take no notice here of that part of the ſubject, but leave it to future inveſtigations and diſcoveries, and content myſelf with—firſt, treating of the Atmoſphere in general as it is expanded by heat, with the motion or winds produced in it thereby, together with the other properties it is found to poſſeſs; and afterwards of water, as it exiſts in the Atmoſphere, under varirious appearances, with its properties, and the effects produced by it.

OF THE ATMOSPHERE IN GENERAL:

Of Heat and Cold in it—Cauſe of the Trade Winds—Of the Sea and Land Breezes, with the Effect theſe Winds have upon each other—And of the Circulation of the Atmoſphere, in variable Winds, over the ATLANTIC Ocean, and the Continents bordering it.

THERE is no doubt but partial heats are produced upon the ſurface of the earth, from ſubterraneous and various other cauſes; but theſe are altogether inſignificant, when compared to the heat of the ſun, which is certainly the moſt univerſal in nature, producing, by his preſence and abſence, the viciſſitude of day and night, the alternate ſucceſſion of ſummer and winter, in the Temperate and Frigid Zones: and from his perpendicular ſituation, cauſes perpetual ſummer in the Equatorial climates: is the cauſe of the variety of the ſeaſons, in all parts of the earth, and is the ſupport, comfort, and nouriſhment of animal and vegetable life: in accompliſhing all which, he muſt have the greateſt effect upon the Atmoſphere, by rarifying it, eſpecially near the ſurface of the earth, and more particularly thoſe parts which lie more immediately under his direct rays, becauſe it is there the greateſt quantity of rays ſtrike in the leaſt ſpace, producing in proportion a greater heat; which being imbibed by this ſurface, part of it is from thence communicated to the Atmoſphere in contact, which, from its greater denſity and contiguity, receives and retains a greater quantity of heat than that at a greater diſtance and elevation.

The Sun's rays muſt communicate heat to the Atmoſphere, upon paſſing through it; but as the heat communicated by the ſun to any ſubſtance, is in proportion to the quantity of rays intercepted and retained, (for thoſe rays that are either reflected by a body, or paſs through by its tranſparency, carry the greater part, if not the whole of their heat along with them); therefore as the Atmoſphere admits great part of the ſun's rays to paſs through it, the heat it receives is only from thoſe rays it intercepts, nearly the whole of which muſt be in the lower regions, becauſe of its greater denſity, and of the vapour floating there; which, together with the heat it receives by communication, and reflection from the ſurface of the earth, muſt make the greateſt heat in the lower regions of the Atmoſphere to be near that ſurface. Indeed it oft happens, that the clouds intercept the greater part of the ſun's rays, in which caſe they will then receive more heat than the ſurface of the earth lying underneath them. But in the higher regions of the Atmoſphere, from its tranſparency, and no vapour floating there, and alſo from the great expanſion or rarification intercepting but very few of the ſun's rays, the heat received will be but trifling indeed.

As one Hemiſphere of the earth is conſtantly enlightened by the ſun, and as the rays ſtrike it in lines parallel to each other, the quantity of rays, with the heat communicated by them to any part of the ſurface of this Hemiſphere, will from its circular form be as the co-ſine of the diſtance, as it increaſes from the central point where the rays ſtrike perpendicular, to the utmoſt verge of the circle that bounds it; and as the Poles are in this circle, when the ſun is in the Equator, therefore by calling the ſun's direct rays, with the heat communicated by them, radius, the quantity of rays, with their heat, incident upon an equal ſpace of ſurface, in each latitude under the meridian the ſun is in, will be as the co-ſine of that latitude, thus decreaſing in a circular proportion to nothing at the Poles, as the ſine complement of the latitude is decreaſed from radius; or as the angle decreaſes in which the ſun's rays ſtrike the horizon.

The greateſt heat in the Atmoſphere being near the ſurface of the earth, it is from thence found to decreaſe, as the altitude increaſes, until at a certain elevation the temperature arrives at freezing. This, beſides the teſtimony of aerial voyagers, is confirmed by the cold being found to increaſe on aſcending high mountains, until at laſt thoſe of an extraordinary height are found covered with ſnow. Now as the earth receives the greateſt heat in the Equatorial climates, becauſe of the ſun's rays being perpendicular, the freezing temperature muſt there be removed to the greateſt height, which from the teſtimony of the Mathematicians, who went to meaſure a degree of the meridian in the province of Quito, in South America, this heighth was found there to be about 2410 Engliſh fathoms, or nearly 2¼ Engliſh miles above the level of the ſea; therefore, ſince the greater part of the Atmoſphere lies above this height, all of which we have reaſon to believe is in a cold froſty ſtate, together with what we obſerve of the increaſe of cold toward the Poles, it appears, that the far greater part of the Atmoſphere ſurrounding our earth is in a continued ſtate of cold, exceeding that of freezing; and only a ſmall part lying near the ſurface that enjoys a warm temperature.

The height of this temperate warmth being, as theſe Mathematicians ſtate, at 2¼ Engliſh miles above the level of the ſea at the Equator, it hence follows, that if the whole Atmoſphere was at reſt, and no winds or other cauſe to agitate and diſturb it, when the ſun was in the Equator, the height of the temperate warmth would from thence decreaſe in elevation toward the Poles, in the ſame proportion as the effect of the ſun's rays upon the ſurface of the earth diminiſhes, or which is the ſame, as the angle in which theſe rays ſtrike the horizon decreaſes from a right one. But from the agitation cauſed in the Atmoſphere from winds, theſe limits of the temperate warmth become very unequal and fluctuating. At the Equator, this fluctuation, by the report of the above-mentioned Mathematicians, appears to be but very little, and from thence increaſing, it becomes very great toward the Poles; being in the firſt place, cauſed there by the warm Atmoſphere being ſometimes driven into the cold regions, by violent guſts of wind, more eſpecially upon the ſurface of the ſea, becauſe of the evenneſs of that ſurface offering leſs impediment to its progreſs, and from the greater warmth of the ſea aſſiſting the warmth of the wind; but again upon the other hand, the cold Atmoſphere, on account of the ſuperior weight, incroaches more, and is more frequently driven into the warm climates, than the warm Atmoſphere is into the cold, particularly upon the land; becauſe of more cold being imbibed and retained by it, than is by the ſea. It alſo happens, that cold Atmoſphere ruſhes into a warm climate, along the ſurface of the earth, carrying its froſt along with it; while higher up, the Atmoſphere over it retains a temperate warmth; from which it may be ſeen, that the temperature of the Atmoſphere, upon the borders of the Polar Frozen Regions, is very fluctuating and uncertain.

But this fluctuation of the temperature of the Atmoſphere is ſtill more increaſed, by the great difference in the ſun's declination; for when the ſun is at his fartheſt declination, in the oppoſite Hemiſphere, the cold, increaſing round the Pole as the ſun recedes, ſpreads to a conſiderable diſtance from it, and incroaches upon the warm climates in many places, more in proportion than the ſun recedes; thereby ſhortening the extent of the temperate regions there, and decreaſing its height, in proportion; from which cauſe we find, that the clouds in winter float at a leſs height than they do in ſummer.

As cold can be produced artificially, that may be aſſigned as part of the reaſon of its great and rapid increaſe by the ſun's abſence, particularly upon the land; for although the preſence and abſence of the ſun be the great and principal cauſe of the general heat and cold, both in the Atmoſphere, and upon the ſurface of the earth, yet it is found, that cold, when accumulated in any particular place, will, by its own action or force, increaſe in a greater proportion than the accumulation does:—for example, a quantity of ice collected in a compact form, in an ice-houſe, will be poſſeſſed of more than double the cold, and preſerve that cold more than double the time, that half the quantity in the ſame form will do, in an equal temperature of warmth; and the greater the quantity of ice that is collected together, the more the cold will be, over and above the proportion of that quantity; in ſo much, that a quantity of ice may be increaſed in magnitude, ſufficient to overcome the influence of a calm Atmoſphere, whoſe temperature is ſeveral degrees above that of freezing; and inſtead of the Atmoſphere thawing the ice, the ice, from its accumulation, would reduce the Atmoſphere to a freezing temperature, for ſome diſtance round, without loſing any of its own cold; or if it loſt ſome of its cold, upon firſt communicating with the Atmoſphere, it would ſoon regain it, by its own active force. From this circumſtance, the cold round the Poles, in addition to its increaſe by the abſence of the ſun, will be farther increaſed, from the accumulation of the quantity of ice and ſnow lying there, ſo that the cold in the lower regions there, moſt probably exceeds that in the higher. Indeed from the Aurora Borealis and Auſtralis, it would appear, that the cold in the higher regions, near the Poles, is not ſo great as at firſt might be imagined; while low down, the cold will be the more intenſe, from the quantity of ſubſtance it has to act upon and ſupport it.

It

It is found, that in the ſouthern Hemiſphere, the cold, with its froſt, extends to a greater diſtance from the Pole, than it does in the northern, which leads many to ſuppoſe, that there is a continent lying under the ſouth polar regions. If this is actually the caſe, a far greater quantity of ſnow and ice will be collected there, than is in the north polar regions, which will account for the extra cold round the ſouth Pole, above that round the north; for the latter is known to have a great deal of ſpace, conſiſting of ſea, which does not imbibe near the cold the land does.

It hath already been obſerved, that wherever the Atmoſphere is rarified by heat, the neareſt, denſe or colder Atmoſphere is immediately put in motion by its weight, and ruſhes in a current toward the lighter or warmer Atmoſphere, in order to reſtore the equilibrium, where it commonly diſplaces the lighter and warmer Atmoſphere, and obliges it to float higher up. This may be exemplified by the following experiments :—Let two vents, communicating with the external Atmoſphere, be made in a room, the one cloſe up to the ceiling, and the other low down near the floor; each being large enough to admit a ſufficiency of Atmoſphere to ſupply the diſcharge of the chimney. Now the door being ſhut, and every vent being cloſe ſtopt, excepting the chimney and the two vents abovementioned; if in cold weather the room is warmed by a fire, the Atmoſphere will be found to ruſh in with great force through the lower vent, while little or none will come in at the upper; and if the vents be each larger than is ſufficient to ſupply the diſcharge of the chimney, a ſlow current will be found moving out through the upper vent. Again, let the chimney vent be ſtopt, and the room warmed by a ſtove, the cold Atmoſphere will ruſh in at the lower vent as before, and will force the warm Atmoſphere in the room, from its being lighter, to ruſh with the ſame velocity out through the upper one; and the warmer the room is made, the quicker this circulation will be carried on: It will alſo be accelerated from the difference in height between the vents being increaſed, on account of the difference in the preſſure of the Atmoſphere upon each. This experiment may be alſo tried, and in froſty weather will be found in ſome meaſure to ſucceed, by applying a lighted candle to the upper and lower parts of the opening of a room door, when about two or three inches diſtant from the door cheek.

After the ſame manner, are motions excited in the Atmoſphere, from the effects of heat and cold, or difference of temperature, exiſting in different places; from whence, as already mentioned, ariſes one of the principal cauſes of winds. For ſince the Atmoſphere, directly underneath the ſun, receives in the lower regions a greater quantity of heat, than that at a diſtance, it will be accordingly more expanded, and by occupying a greater ſpace, will elevate the column there to a greater height. This greater rarification in the lower regions will induce the neighbouring cooler Atmoſphere from its ſuperior weight to move toward this rarer, in order to reſtore the equilibrium; and by obliging the rarer and lighter Atmoſphere to give place to it, and float higher, will elevate the column ſtill more, which from its ſuperior height will deſcend by its gravity toward the vacancy made by the ſinking down of the Atmoſphere, to fill the ſpace left by the removal of the denſe toward the rarer Atmoſphere below; and thus a circulation will be carried on of the colder Atmoſphere in the lower region flowing toward the warmer, and the contrary in the higher.

But as the diurnal motion of the earth cauſes the ſun's perpendicular rays incident upon its ſurface to be continually ſhifting their place from Eaſt to Weſt, the colder Atmoſphere in the lower region which moves in from the Eaſt, toward where the ſun's rays are perpendicular, will have a greater diſtance to move, and conſequently muſt accelerate its motion toward overtaking the ſun; whereas the motion of that from the Weſt is retarded by the ſun's direct rays meeting it, by which means the Atmoſphere from the Eaſt from its greater velocity will overcome that from the Weſt, and force it back again with a motion equal to the difference of their velocities; and thus a weſtern motion having commenced, the ſucceſſive impulſes it receives from the ſun's diurnal motion will continue and confirm it; for if the ſun, upon once paſſing the meridian, produces from the above cauſe a weſtern motion in the Atmoſphere, the ſecond time he paſſes will increaſe that motion, and ſo will the third, until the quantity of motion balance the cauſe that produces it. Thus the trade-winds, ſo well known in the Atlantic and Pacific Oceans, may be accounted for; and this theory alſo agrees in every circumſtance with what we obſerve concerning the trade-winds; for they are found to blow ſtrongeſt near the ſurface of the ſea, becauſe the effect of the ſun's heat that produces them is greateſt there. They are feebleſt in the forenoon, becauſe the greateſt time has then elapſed ſince they received their laſt impulſe, and the Atmoſphere Weſt of the ſun will have become denſer from the cold of the preceding night, and therefore reſiſt the force of that from the Eaſtward in puſhing it on; and they blow ſtrongeſt in the afternoon, becauſe they have then received a freſh impulſe from the ſun paſſing the meridian; and from the rarefication of the Atmoſphere underneath his direct rays to the Weſtward, that from the Eaſtward is facilitated to ruſh in for reſtoring the equilibrium.

The trade-winds being produced by this cauſe, it will evidently appear, that if the earth was covered with water, and winds produced from no other cauſe than the heat of the ſun, that in the lower regions about the equator, the trade-winds would blow continually round it, and that (agreeable to the above theory) a wind would in the lower region proceed from the Poles, from being coldeſt there toward the equator, accelerating its motion, and tending more and more to the Weſtward as it approached, until at laſt it would join the trade-winds, and finally proceed with them; while in the higher region, becauſe of the greater elevation of the column about the equator, from the greater heat there, and the influx below of Atmoſphere from the Poles, a motion would be carried on by the Atmoſphere deſcending by its gravity through the higher region, from this greater elevation toward the Poles, in order to preſerve the level, and ſupply the deficiency cauſed by the Atmoſphere ſinking down there, to fill the vacancy made by that below moving toward the equator.

But the circulation of the trade-winds round the earth is interrupted by the land lying in its way, becauſe of its elevation above the level of the ſea, and the unevenneſs of its ſurface, which hinders the current of Atmoſphere in gliding over it. It is true, that the ſun's meridian heat is greater upon the land than it is upon the ſea, becauſe in the former the ſun's rays not penetrating below the ſurface, are with their heat retained there, and thus reflect and communicate more of that heat to the Atmoſphere contiguous to and in contact with it; and would produce a ſtronger trade-wind than that upon the ſea, provided the ſurface was as ſmooth and even, and upon as low a level, with a ſufficiency of extent to propagate it.—

But the ſurface of the land, in addition to its being of a greater elevation, is compoſed of vallies and hills lying in various directions, the former of which receives far more heat than the latter; therefore the expanſion of the Atmoſphere by heat being confined to the former, prevents the regular progreſs of this expanſion moving along with the ſun, like as it does upon the ſea, and of conſequence prevents that regular motion in the Atmoſphere cauſed by it upon the latter. Alſo theſe hills and vallies, beſides their unevenneſs, are often covered with woods, which from the continual great preſſure of the incumbent column upon the ſurface, and the trade-winds reaching to but a ſmall height, hinders by their ſhaggineſs its proceeding over them.

Again, in addition to the above obſtacles to the general circulation of the trade-winds round the earth, thoſe upon the Atlantic Ocean are more effectually obſtructed in their further progreſs, by that immenſe ridge of high land and mountains called the Andes and Cordilleras, ſtretching North and South through the Continent of America, which by being of a greater height than the trade-winds blow, forms a complete bank or barrier to hinder their further progreſs that way; therefore the trade-winds being thus obſtructed by the Continent of America, they return by a circuitous direction to the Eaſtward, over the North and South Atlantic, to the Continents of Europe and Africa; and as the trade-winds from the Indian ſeas are prevented by the Continent of Africa from proceeding from thence to the Weſtward, this return of the winds to the Eaſtward over the North and South Atlantic is facilitated and encouraged to proceed, for the purpoſe of ſupplying the ſource of the trade-winds, which continually flow from the Continent of Africa toward the Continent of America; thus a circulation of Atmoſphere on each ſide the equator is carried on upon the Atlantic Ocean; by the part which returns from America to the Weſt coaſt of Europe and N. W. coaſt of Africa, forming the prevailing Weſt winds upon the North Atlantic, and that which returns from the South American coaſt toward the Cape of Good Hope and the Southern Weſt coaſt of Africa forming the prevailing Weſt winds in that ocean upon the South ſide.

That the trade-winds blow ſtrongeſt on the ſurface of the ſea, and from thence decreaſe in ſtrength as the altitude increaſes, is evident from the cauſes that produce them; for as their production is the conſequence of the extra heat imparted by the ſun's meridian rays, and as this heat acts chiefly upon and near the ſurface of the earth, its effects muſt be greateſt there; therefore the trade-winds being produced by theſe effects, they conſequently muſt be ſtrongeſt there; which is farther corroborated by their ſtrength being found to decreaſe upon aſcending high mountains; in ſo much ſo, that the clouds are continually ſeen reſting during the whole day upon the tops of the mountains in the Weſt India Iſlands (although none of theſe mountains exceed three quarters of an Engliſh mile in perpendicular height) becauſe at that height the wind hath not ſufficient ſtrength to overcome the attraction of the clouds to the mountains, although at the ſame time it is blowing a ſtrong gale upon the ſurface of the ſea round their baſe. I have alſo among the Weſt India Iſlands frequently obſerved the high thin white clouds moving to the Eaſtward, notwithſtanding during the ſame time the trade-winds below blew a briſk gale to the Weſtward; from all which circumſtances I am led to believe, that the trade-winds ſeldom reach above a mile in perpendicular height, and that at half a mile high they are but very feeble.

From the tranſparency of water, the ſun's rays, incident upon the ſurface of the ſea, will have part of them reflected back through the Atmoſphere, and another (perhaps the greater) part will penetrate to a conſiderable depth down through the water, where by being continually intercepted by the parts of the water in its progreſs downward, will at a great depth be at laſt exhauſted; and it muſt be from this interception of the ſun's rays that the ſurface and upper parts of the ſea, in the equatorial climates, are found to be warmer than thoſe low down; therefore ſince the ſurface of the ſea retains only a ſmall part of the ſun's rays, with the heat communicated by them, the Atmoſphere upon it muſt receive but very little of its heat by reflection from the ſea; by which it appears that the chief part of the heat received by the Atmoſphere upon the ſea in the equatorial climates, muſt be from the ſun's rays intercepted by it, and by clouds and vapour there; which accounts for the weather upon the ſea in thoſe climates being leſs warm than that upon the land. But the temperature upon the ſea being uniform every where, the increaſe of the ſun's meridian heat, and its effect upon the particular place it acts upon in his progreſs through his diurnal circuit, is from this regularity more ſuſceptible of giving motion to the Atmoſphere in producing the trade-winds, than it is upon the land, which together with the evenneſs of the ſurface, is the reaſon of the trade-winds being ſo regular upon the ocean, where there is extent enough to produce them.

The land, from its opacity, reflecting leſs of the ſun's rays than the ſea, and from its ſolidity of ſubſtance ſuffering none of the rays to penetrate below the ſurface, it therefore imbibes and retains a greater quantity of heat, eſpecially in the day time, when the ſun is in or near the meridian, conſequently it reflects and communicates more of that heat to the Atmoſphere near and in contact with it, by which means it is more rarefied than the Atmoſphere upon the ſea, which induces that upon the latter, from its ſuperior weight, to ruſh in upon the land, in order to reſtore the equilibrium, conſtituting what ſailors call the *ſea breeze*, which by accumulation elevates the column to a great height, where it diſperſes in the higher region toward where it eaſieſt finds vent. The ſea breezes are found to blow ſtrongeſt during the day, becauſe of the land being then moſt heated by theſun, and to ceaſe toward night, becauſe then the Atmoſphere and ſurface of the land turns cool by the withdrawing of the ſun's influence. The Atmoſphere thus becoming as denſe or denſer than that upon the ſea, hinders any further influx, and a ſmall breeze called the *land-breeze* iſſues from the land to the ſea. But as the night temperature upon the land is ſeldom much below the temperature at the ſame level upon the ſea, the land breeze is therefore in general but very faint, unleſs aſſiſted by ſome other cauſe. Indeed the land breeze is no doubt often the effect of ſome of the accumulation of Atmoſphere cauſed by the ſea breeze during the day returning at night.

As the ſea breezes are cauſed only by the greater heat upon the land above that upon the ſea, they can only prevail upon the ſhore and near it; from thence their influence and force muſt decreaſe, as the diſtance from ſhore increaſes, until at laſt they ceaſe altogether. The ſtrength and force of the ſea breezes will be greater in proportion to the greater heat and extent of the land that cauſe them;—and the greater this force, the farther will their influence reach from the ſhore. Therefore, where the trade-winds come within this influence,

fluence, they will have a conſiderable effect upon each other, in proportion to their relative ſtrengths and difference in directions.—Thus, upon the South ſide of Jamaica, and Hiſpaniola, the wind which blows during the day is compounded of the ſea breeze, which of itſelf would blow directly upon the land from South, and of the trade-wind blowing from Eaſt, and is therefore from S. E. and from the ſame cauſe the land breeze there blows from N. E. but being very feeble, the influence of the land-breeze reaches very little beyond the ſhore. In like manner, and from the ſame cauſes, the ſea breeze upon the North ſide of theſe Iſlands blows from N. E. and the land breeze from S. E. To leeward of theſe Iſlands, the ſea breeze acts in oppoſition to the trade-winds, and where the extent of land is ſufficient to produce a ſtrong ſea breeze, it often balances the trade-wind, producing a calm during the heat of the day, or by overcoming the trade-wind, produces a breeze in oppoſition to it; and upon the windward, or Eaſt end of theſe Iſlands or other lands in the equatorial climates, the ſea breeze and trade-wind uniting, blow ſtrong during the day, but turn feeble toward night, on account of the oppoſition from the land breeze.

Upon the coaſts of large continents, where the accumulation of heat is very great, the ſea breeze often overcomes that part of the trade-winds which comes within its limits, more eſpecially when near the ſhore; an inſtance of which is to be found upon the Southern or Guinea Coaſt of Africa, where we find the ſea breeze, from its ſuperior force, firſt to affect and at laſt overcome the trade-wind, by gradually inclining it from the N. W. direction, toward which it blows upon the South ſide of that part of the equator that lies oppoſite this coaſt, and altering its courſe, firſt to North, and from thence, as it nears the coaſt, to the Eaſtward, until near to and upon the ſhore, where it blows to the E. N. E. This ſea breeze muſt no doubt be in a great meaſure cauſed by the great heat of the extenſive country and ſandy deſerts in the interior, and as theſe deſerts lie in an Eaſtern direction from this part of the coaſt, the ſea breeze will of conſequence be drawn to the Eaſtward toward them. But there is another circumſtance which no doubt gives additional ſtrength to this wind, and inclines it more to the Eaſtward than otherwiſe it would be, which is, the poſition of this coaſt, compared with the coaſt from the Gulf of Guinea to the Southward, toward the Cape of Good Hope, as they lie with reſpect to the ſupply of Atmoſphere for carrying on the ſouthern part of the trade-winds.—This ſupply begins its motion upon the ſea adjacent to the Cape of Good Hope, and the coaſt North from it, and from thence proceeds with an accelerated velocity, firſt North, and afterwards tending to the weſtward, the farther it advances. Now the northern direction of the eaſtern part of this wind being nearly in a direction toward the face of the ſhore between Cape Palmas and the Gulf of Guinea, it as it were preſſes the Atmoſphere upon this coaſt, which, with the ſea breeze at the ſame time drawing it in, muſt neceſſarily, by increaſing this preſſure, cauſe an accumulation of the Atmoſphere upon it, which from the eaſtern inclination of the ſea breeze, will find vent by diſcharging itſelf to the eaſtward, in order to ſupply the deficiency cauſed by the drain of Atmoſphere, carried away from out of the Gulf of Guinea by the trade-wind; for the Gulf of Guinea lying ſo far North with reſpect to the coaſt to the weſtward of it, makes it difficult for a ſupply to come from the ſouthward upon it, becauſe of the conſtant drain to the weſtward, from theſe ſouthern coaſts preventing this ſupply proceeding North, together with the diſtance it has to proceed; therefore the ſea breeze and influx of Atmoſphere upon this South coaſt is facilitated in its courſe to the eaſtward for ſupplying this drain, juſt upon the ſame principle that we ſee a ſtream paſſing through one ſide of a pond produce a returning eddy in the other.

Many more inſtances of the ſea breeze overcoming the trade-winds may be found in different parts of the world, particularly in the Eaſt Indies, where, from the vaſt extent of continent (the ſouthern coaſts of which reaching near the equator the more readily produce ſea breezes) and from great and numerous iſlands in the Indian ſeas, and between them and the Pacific Ocean, the ſea breezes of which, with thoſe of the continents in many places, alter and overcome the trade-winds that come within their influence, in proportion to their ſeveral poſitions and ſituations, according to the degrees of heat they receive from the ſun in the different ſeaſons of the year; all of which directions of trade-winds, as acted upon by ſea breezes, may be readily accounted for by the foregoing theory. But having never been in thoſe ſeas, I ſhall leave the deſcription of the winds in them to thoſe more converſant with, and of more ability to explain them;

contenting myſelf at preſent with obſerving, that the variety cauſed in the direction of the winds in thoſe ſeas by the influence of the ſea breezes there, muſt be a very material hindrance to the general circulation of the trade-winds round the earth, by diverting them from their original weſtern direction; in ſo much ſo, that upon the Eaſt coaſt of Africa they are ſo enfeebled, and their direction ſo altered, that they act but with little force, and make little or no effort to overcome the obſtruction they meet with from that continent, in their farther progreſs to the weſtward; by which means the trade-winds generated upon the Atlantic Ocean are left at free liberty to carry on their circulation there.

In the above theory of the trade-winds it is to be obſerved, that as they have their origin and direction from the diurnal motion and immediate influence of the ſun, and as that influence is greateſt where his rays are perpendicular, it muſt therefore vary with his declination. Thus we find, that when the ſun hath a South declination, the trade-winds South of the Equator have their direction more to the weſtward, and thoſe North of the Equator more to the ſouthward, and that the contrary takes place when the ſun hath a North declination, by the ſouthern trade-winds blowing more to the northward, and the northern trade-winds more to the weſtward.—Alſo the ſea breezes are always ſtrongeſt, and incline toward where the ſun is vertical; ſo that it evidently appears, that agreeable to the theory of the Atmoſphere in the lower region always moving toward where the greateſt heat is, ſo the winds are found always to tend toward where the ſun is vertical, becauſe of the greateſt heat being there; and upon theſe and the foregoing principles, may all the conſtant and periodical winds in the Torrid Zone and near it be accounted for; obſerving always, that the land there receives more heat than the ſea, and loſes that heat ſooner.

Having thus explained the cauſe of the trade-winds and ſea breezes, with their effects upon each other, as they are found to take place between the Tropics, I ſhall now proceed to deſcribe the circulation of the Atmoſphere cauſed by theſe winds upon the Atlantic Ocean and the coaſts bordering it; more particularly thoſe parts which lie North of the Equator; becauſe being moſt frequented, they are better known, and conſequently of greater conſideration.

The ſupply of Atmoſphere for the northern part of the trade-winds generally begins its motion upon the ſeas adjacent to the iſland of Madeira, between it and the Straits Mouth, and along the coaſt of Africa South of theſe; from thence it proceeds S. W. toward the Canary Iſlands, where, and upon the adjacent ſea, the winds becoming conſtant and ſteady, are denominated the *trade-winds;* from thence they continue proceeding S. W. until they join the S. E. trade-winds from upon the Equator to about the latitude of 10 North, according to the ſun's declination, the joining being to the ſouthward with South declination, and to the northward with North. After joining, they proceed together Weſt for the Weſt Indies.

Along the N. W. coaſt of Africa, the wind near the ſhore proceeds from Cape Bajadore S. S. W. along the coaſt, to Cape Verd, being induced to blow in this direction in order to ſupply the deficiency cauſed by the drain of Atmoſphere carried to the weſtward from off the coaſt to the northward of Cape Palmas. But as the coaſt to the ſouthward of Cape Verd tends to the eaſtward of South, the northerly winds then leave the direction of the ſhore, and become feeble, fluctuating, and ſqually, but ſtill continue their ſoutherly direction for the above purpoſe, of ſupplying the ſource of the trade-winds; but that ſupply becoming very ſcanty, the trade-winds from this coaſt, to as far Weſt as the longitude of 20. or perhaps farther, are but very fluctuating, ſqually, and rainy, particularly when the ſun hath north declination, becauſe then the winds from the northward, for the purpoſe of ſupplying them, are at that time leaſt inclined to proceed to the ſouthward. In this part of the coaſt, the ſea breeze, from the great heat of the land, ought to have a conſiderable effect, and during the day is found to help the progreſs of the ſoutherly winds; but its direct effect is greatly diminiſhed by the continual drain of Atmoſphere from off this coaſt, and carried away by the trade-winds. From this circumſtance it would be readily imagined, that the land breeze during the night would blow with great force; but this is not the caſe; becauſe in the firſt place there is no accumulation of Atmoſphere from a ſea breeze, to diſcharge from off the land; and again, the heat upon the land never abating during the night, ſo as to be of a temperature below what it is at ſea during that time, therefore the land breeze, tho' moderate, is of no great ſtrength.

The ſupply of Atmoſphere for the ſouthern trade-winds, begins its motion upon the ſea adjacent to the coaſt north from the Cape of Good Hope; from thence it proceeds to the northward, until at the ſouthern Tropic, where altering its courſe more to the weſtward, it there becomes conſtant and ſteady, and from thence is denominated the Trade-wind. After part of the trade-winds make the circuit cauſed by the ſea breeze upon the ſouth coaſt of Guinea, they proceed to the N. W. where, joining the northern half of the trade-winds, they proceed together to the weſtward for the coaſts of America.

It may be obſerved, from the form of this ocean, that the ſouthern trade-winds commence farther to the eaſtward than the northern; and that the northern part of the trade-winds proceed farther to the weſtward upon the Carribbean ſea, than the ſouthern can do; ſo that the greateſt extent of ſea upon which the trade-winds upon the Atlantic blow, is not in the direct line of their courſe, but angularly from the S. E. to N. W. Now the winds are more inclined to proceed with the direction of the ſea, than they are to proceed upon the land, becauſe the latter forms a bank to conduct them upon the former, as a channel where they are facilitated to proceed, by meeting with leſs obſtruction on account of the evenneſs of the ſurface: ſo that this angular direction of the ſea inclines the wind more from the ſouthward, and is the reaſon of the S. E. trade-winds penetrating ſo far to the northward of the Equator.

The conſtant influx of the trade-winds upon the continent of America cauſing an accumulation of Atmoſphere there, muſt elevate the column to a great height, and this height is ſtill made greater by the great heat of the climate. This column will from its ſuperior height, diſperſe toward the North and South, becauſe of the greater facility with which it is led to flow in theſe directions, from the leſs elevation of the column there, on account of its condenſation by the cold.

The general North and South motion of the Atmoſphere in the upper regions, from the Equator toward the Poles, has in the former part of this ſubject been ſhewn to be cauſed by the greater heat of the ſun in the equatorial climates, and by the greater cold in the polar. In this it may be proper to obſerve, that although the column of Atmoſphere is higheſt at the Equator, yet the weight or preſſure of the column there is leſs in proportion to its altitude than it is at the Poles, on account of the heat in the lower regions diminiſhing its denſity. This diminution of denſity muſt begin at the upper limits of the temperate warmth, and from thence become more and more as the heat increaſes to the ſurface of the earth, where the diminution of denſity is moſt from what the calculation from preſſure would otherwiſe give; from which circumſtance the upper limits of the temperate warmth being raiſed higher by the rarefication below, and ſtill ſupporting the ſame length of column over it, as if it had not been raiſed, its denſity will be greater than the calculation for denſity at that height would otherwiſe give; and conſequently greater than the denſity at the ſame height in the colder regions toward the Poles; from which it appears, that the greateſt difference in denſity at an equal altitude will be about the upper limits of the temperate warmth; therefore it will be there that the motion in the Atmoſphere, from the Equator toward the Poles, will be principally carried on. And ſince the Atmoſphere near the Poles is, from its greater weight, flowing continually off toward the warmer climates in the lower region, the motion through the region at the upper limits of the temperate warmth above deſcribed, for ſupplying the deficiency cauſed by this flowing off below, will be carried on at a leſs altitude, on account of the communication being more direct.

The Atmoſphere in the upper regions will be prevented from proceeding to the weſtward, beeauſe the heat upon the Weſt coaſt of America, bordering the Pacific Ocean, is equally as great as that upon the eaſtern coaſt, by which the column will be equally as much elevated, and its denſity in all its parts nearly the ſame, beſides which the Andes and Cordilleras lie as a barrier to obſtruct its paſſage that way.

The province of Quito upon the Andes, lying in a ſituation not much below the upper limits of the temperate warmth, and the Cordilleras or mountains there riſing above that height, the North and South motion of the Atmoſphere above deſcribed, that is carried on at this height, is teſtified by Don Ulloa, one of the Mathematicians who were deputed to meaſure a degree of the meridian in that country about the year 1737, and continued near 9 years in it; for ſpeaking of the winds in Quito, he ſays, that they blow continually, but never with any violence; their uſual directions are North and South, tho' they ſometimes ſhift to other quarters, without any regard to the ſeaſon of the year; by which we ſee that North and South is the general tendency of the winds there, which correſponds with the above theory; only being upon the Equator, the ſeparation in their direction toward each Pole muſt make them more variable at this place, than they would be upon the ſame elevation at any conſiderable diſtance North or South from it. Alſo the mountains, by obſtructing and altering the direction of the winds, muſt increaſe their variation.

The accumulation of Atmoſphere from the trade-winds flowing upon the continent of South America, will be diſcharged by its deſcending to the ſouthward thro' the upper region toward the colder climates there, and from thence flowing to the eaſtward along the South Atlantic toward the Cape of Good Hope, forming the prevailing Weſt winds in that ocean, which afterwards, by proceeding to the northward, along the coaſt of Africa, join the ſouthern trade-wind, and by proceeding to the weſtward with it, completes the circulation in that hemiſphere.

In like manner does the accumulated Atmoſphere flow to the northward over the continent of North America and the Atlantic Ocean bordering it. In the winter ſeaſon, this flowing off to the northward, is carried on principally through the upper region over the land, and being condenſed by the cold there, it returns through the lower region to the ſouthward and eaſtward, upon the principle already mentioned, of the cold Atmoſphere in the lower region always flowing by its ſuperior weight toward the equatorial or warmeſt climates, and the contrary in the higher regions; only the eaſtern direction it takes here, is in order to carry on the circulation.

Here it will be proper to obſerve, that the uniform motion and regularity of the trade-winds in the middle of the ocean is diſturbed, upon approaching to and entering upon the land, becauſe of the inequality of its ſurface, the different degrees of heat upon it, and more particularly by the falls of rain, with various other cauſes; ſo that in the Weſt Indies the weather, as to ſeaſons, begins to vary, and the uniformity of the winds both in ſtrength and direction is ſometimes diſturbed; upon the continent of N. America the variation of the winds and weather is increaſed and becomes very great, owing to the difference there is in the temperature of the ſeaſons, upon advancing North toward the vicinity of the cold climates, and by conſidering the great extent of ſpace from the Northern Tropic to the Pole, that the circulation has to return thro' to the eaſtward acroſs the Atlantic, and that only the northern half of the trade-winds return that way, its motion through this great ſpace muſt be ſlow, partial, and variable, which from the obſtruction of mountains, direction of valleys, fluctuation and difference in temperature, with the effects of evaporation, clouds, and ſhowers, muſt render the winds in the northern climates very variable, both upon the land and ſea, particularly the former; ſo that the circulation of the Atmoſphere to the eaſtward, for ſupplying the ſource of the trade-winds in every part of its circuit, can only be eſtimated by its general tendency that way in the prevailing winds in thoſe directions, above thoſe in any other.

Toward the end of autumn, when the ſun declining South, is withdrawing his preſence from the North polar climates, the froſt then takes poſſeſſion of the regions round the Pole, and from thence, as the ſun recedes, it advances in every direction to the ſouthward, thereby enlarging the circumference of the ſpace where the warm temperature borders upon freezing, until the latter end of winter, when a great part of the northern Hemiſphere is occupied by the froſt. Thus when the cold has advanced far to the ſouthward, and becomes ſevere upon the northern continents, particularly upon that of America, it often happens, that the flow of heavy Atmoſphere from this froſty maſs toward the warmer climates to the ſouthward is more abundant from the Eaſt coaſt of N. America than is neceſſary for croſſing the Atlantic for ſupplying the ſource of the northern trade-winds; therefore we frequently find a part of this flow of cold Atmoſphere proceed to the ſouthward and eaſtward, paſt the iſlands of Bermuda, forming the N. W. gales, ſo well known upon this coaſt, where by joining the trade-winds there, completes a revolution within that ſhort ſpace.

Theſe N. W. gales are promoted by the warmth of the Atlantic ocean bordering this coaſt, but more eſpecially by the greater warmth of a ſtream of warm water, commonly called the Gulf-ſtream, that flows continually from the Weſt Indies North through the Gulf of Florida, and from thence to the northward and eaſtward along this coaſt, until paſt the Banks of Newfoundland, and which, by communicating its warmth to the Atmoſphere over it, facilitates the influx of the cold froſty air from off the land; and from this froſty air flowing ſo fluently from off the continent of North America upon the Atlantic, the higher Atmoſphere there, ſinking down to fill its place, muſt leave a conſiderable quantity of vacant ſpace in the upper region, which will facilitate the deſcent of the higher Atmoſphere from the ſouthward to fill it up, which again will facilitate the influx of the trade-winds into the bay of Mexico. Hence we ſee the reaſon of the trade-winds being briſker among the Weſt India Iſlands during the time the cold is intenſe, and far to the ſouthward upon the continent of America, than they are at any other ſeaſon; and of the trade-winds preſerving their limits at the ſame diſtance to the northward, when the ſun hath South declination, as they do when he has North.

The heavy froſty Atmoſphere, in flowing from off the land of N. America, commonly burſts to the eaſtward, through one or more valleys near each other, while at the ſame time upon another part of the coaſt, at a diſtance from this, there may be but little wind that way, or perhaps calm. The force and quantity with which the Atmoſphere ruſhes through theſe valleys, often exceeds the ſupply from the warmer climates in the upper region, and will continue not only until the accumulation is done away, but often until an exhauſtion takes place, whoſe counter force is ſufficient to overcome the velocity of that flowing off; conſequently the moment the moving off ceaſes, a motion will commence the contrary way, and continue until the exhauſtion is filled up. This contrary motion will be but ſhort, becauſe the ſupply by the circulation from the ſouthward continuing to flow in, will now ruſh in with increaſed force. Again, upon a ſecond accumulation, the vent may burſt out in another place, producing the ſame effect; and agreeably to this theory we ſee that the N. W. gales upon the Eaſt coaſt of N. America, never blow alike in all places, but are very partial, and frequently exhauſting themſelves by their force, and cauſing a ſhort interval of eaſterly wind to ſucceed them; and in like manner it is very probable, when the ſummer heat has confined the froſt to a ſmall ſpace round the North Pole, that from the near approach of the North Atlantic and North Pacific Seas to this Pole, the froſty winds flowing out upon one of theſe ſeas may cauſe an exhauſtion, ſo as to produce a wind from the ſouthward in the oppoſite ſea, in order to fill it up; ſo that it is moſt probably owing to this cauſe, that ſoutherly gales ſometimes happen in Greenland; for I dare ſay that northerly gales of a ſimilar nature (if ever they happen) are very rare upon the borders of the ice round the South Pole.

In the ſummer ſeaſon, the weather for a conſiderable way North upon the continent of America, is as warm, or nearly ſo, as it is in the equatorial climates, conſequently the column of Atmoſphere will be equally as much elevated; ſo that there will be little or no deſcent for it in the higher regions, to facilitate its moving to the northward there; therefore any movement to the northward muſt be carried on by a ſlow motion through the lower region, ſo that from this obſtruction to its motion to the northward upon the land, we find a flow of Atmoſphere to the northward upon the ſea abreaſt the Weſt India Iſlands, by the trade-wind flowing from its northern limits to the northward and eaſtward in S. W. winds, which at this ſeaſon are found to prevail in the lower region over the ſea, along the American coaſt, and on each ſide the Bermuda Iſlands; for it is then common for a ſhip from the Weſt India Iſlands, bound to the northward, when coming near the North limits of the trade-winds, to find the wind veer from Eaſt to S. E. then to South; and thus it veers as ſhe advances to the northward, until at laſt it comes to S. W. or W. S. W. ſo that in this manner does part of the trade-winds during the ſummer ſeaſon circulate to the northward along the ſurface of the ſea, and the reſt over the continent of America by ſlow motions in the lower region, until it come to the borders of the cold, where the northern motion is transferred to the higher region as above deſcribed, and a motion toward the warmer climates commences below.

The want of vent to the northward over the continent of America muſt, during the ſummer, produce an accumulation of Atmoſphere upon the Bay of Mexico, and the ſeas and coaſts adjacent; therefore it is probable that part of this accumulated Atmoſphere is forced through and eſcapes between the mountains over the Iſthmus of Darien upon the Pacific Ocean; and that the prevailing Weſt winds blowing round Cape Horn, as deſcribed by Anſon and other circumnavigators, are for the purpoſe of ſupplying the deficiency cauſed in the Atlantic by Atmoſphere eſcaping that way.

Alſo this accumulation prevents in a great meaſure a ſea breeze, which during the hot ſummer weather would otherwiſe blow in upon the land, along the ſouthern coaſts of the United States, as far to the northward as New York. It is true, the prevailing S. W. winds that blow along theſe coaſts, tend more from the ſouthward during the heat of the day, but not ſo much upon the ſhore as the heat of the land might otherwiſe cauſe it. But along this coaſt the land breeze during the night is common during ſettled weather. To the eaſtward of New York, along the coaſts of New England, Nova Scotia, and the ſouthern coaſts of Newfoundland, where the effects of this accumulation do not reach, the ſea breeze generally prevails during fine weather blowing ſtrong from the ſouthward, toward which it is facilitated for ſupplying the eaſtern circulation carried on in the Greenland and other northern ſeas at this ſeaſon.

The warmth communicated to the weſtern coaſts of Europe, by the prevailing weſterly winds, with the vapour carried by them from off the ocean upon theſe coaſts, and from the ſea ſurrounding the North Cape by its warmth, and the facility it affords to the weſterly winds to proceed round it, checking the ſeverity of the froſt upon its coaſt, and hindering the Greenland froſt from communicating with them, together with the higher degree of cultivation, the fewer foreſts, the greater number of inhabitants, cattle, &c. hinders the winter cold from penetrating ſo far to the ſouthward there, as it does upon the North American continent, and facilitates the returning influence of the ſun in commencing ſooner, and penetrating farther to the northward in the ſpring and ſummer; by which means the weſtern European coaſts are at this ſeaſon warmer than the American eaſtern coaſts under the ſame parallel, which will of conſequence produce an eaſtern current of Atmoſphere over theſe ſeas, by its flowing from the colder continent toward the warmer, and, as mentioned before, it is to ſupply this circulation in the northern ſeas, that the winds prevail ſo much from the ſouthward upon the coaſts of New England, Nova Scotia, and Newfoundland; alſo the ſudden and heavy gales of ſoutherly winds that frequently happen upon the North American coaſts are no doubt cauſed by Atmoſphere ruſhing to the northward to ſupply exhauſtions cauſed by this circulation to the eaſtward in the Greenland ſeas.

The ſpace for the weſterly winds, for carrying on the general circulation to the eaſtward acroſs the Atlantic Ocean, being greatly enlarged during the ſummer, ſo as to become too extenſive for the quantity of Atmoſphere neceſſary to carry on the circulation to maintain a conſtant current over all its parts; therefore it commonly happens, from the elaſticity and other properties of the Atmoſphere, together with cauſes already enumerated, that the directions of the winds are fluctuating and variable; ſo that as already mentioned, it is only by what the motion to the eaſtward exceeds that to the weſtward, that the general circulation is to be calculated. The winds upon the ſea not being ſo changeable as thoſe upon the land, it continues longer in the ſame direction, after having once ſet in; an inſtance of which I was told happened a few years ago: —A packet arriving at Halifax from Falmouth, after a paſſage of 21 days, having an eaſterly wind all the way, which is directly contrary to the general circulation; yet this argues but little againſt it, becauſe from the ſpace being ſo extenſive, this eaſterly wind might not prevail in all parts of it during that time, and a weſterly wind in another place might compenſate ſufficiently for the eaſterly wind here. Beſides it may be many years before a ſimilar inſtance of ſuch a paſſage from an eaſterly wind happen again, although ſuch paſſages from Halifax to England by weſterly winds are very common.

The general circulation of the Atmoſphere from the coaſts of the United States to the coaſts of Europe, is carried on chiefly between the Banks of Newfoundland and the Weſtern Iſlands, and it is there where the weſterly winds are moſt prevalent. After paſſing the Banks of Newfoundland, theſe winds, eſpecially in the ſummer ſeaſon, are inclined to proceed more to the northward, from the leſs obſtruction they meet with that way upon the ſurface of the ocean, and poſition of the European coaſts, and from the great quantity of vapour riſing in the ſouthern climates, moving to the northward, in order to ſupply the fall of rain, hail, and ſnow, in the northern climates; alſo the vent round the North Cape inclines them more to the northward, where after rounding the Lapland coaſts, the circulation that way proceeds up the White Sea, over Ruſſia and the reſt of Europe, to the Mediterranean.

During the winter ſeaſon, the circulation to the eaſtward over the Greenland ſeas is ſtopped by the froſt, by which the general circulation is confined to the ſouthward of Newfoundland, having its chief ſtrength and direction between the Banks of Newfoundland and the Weſtern Iſlands, which appears to be the principal channel for it in all ſeaſons. But in the winter, from its being chiefly confined to this ſpace, we find it carried on with greater force than in ſummer; hence the weſterly winds are at this ſeaſon more conſtant, and of greater force, than they are in ſummer, as alſo the wind from the cold Atmoſphere to the northward blowing to the ſouthward, joins the weſterly wind, and proceeding with it, increaſes its ſtrength; for it is found, that the more North the latitude, the more from the North in general the wind is; for inſtance, a ſhip paſſing the Banks of Newfoundland at this ſeaſon, will moſt probably have the wind at N. W. while at the ſame time another ſhip, due South from the firſt, in latitude 36 or 38, may have the wind at Weſt, W. S. W. or perhaps S. W. Now it is evident, that at the joining of theſe winds, it muſt blow ſtronger than at a diſtance from it, which is frequently experienced by ſhips paſſing in this tract. Alſo it often happens, during ſevere cold winter gales, that the meeting of the Weſt and N. W. winds produces whirls, raiſing the water, and carrying it in form of drift with them to conſiderable heights. Theſe are by ſailors termed *white ſqualls*, from their being ſeldom accompanied by a cloud.

Between the above-mentioned channel of the weſterly winds, and the North limits of the trade-winds, (that is) the ſpace comprehended between the Weſtern Iſlands and Madeira on the Eaſt ſide, and the Bermudas on the Weſt, the winds are found more variable (eſpecially in the ſummer time) and the weſterly winds leſs frequent, than they are immediately to the northward, which perhaps the Weſtern Iſlands may in ſome meaſure contribute to, by obſtructing their paſſage, therefore eaſterly winds frequently prevail here continuing ſome days at a time. The ſouthern part of this ſpace bordering upon the trade-winds, is, during both ſummer and winter, more frequented with calms than any other part of the ocean, on account of its ſituation lying between where the northerly winds flow in to ſupply the trade-winds on the eaſt ſide, and where the trade-winds branching out from their North limits, flow to the northward upon the ocean on the Weſt ſide. But all theſe general directions of the winds on the Atlantic ocean are continually diſturbed and altered, from various cauſes, as well as by the great quantity of vapour which is continually riſing, condenſing into clouds, and aſſembling in maſſes, fall in rain.

The ſtream of weſterly or S. W. winds which blow between the Banks of Newfoundland and the Weſtern Iſlands, generally bend their courſe to the Britiſh Iſles, and North coaſt of France. When moderate and ſteady, they upon paſſing the mountains and high lands on the Weſt of Britain and Ireland, have their current ſometimes transferred to the higher region, becauſe of theſe mountains obſtructing it low down; and from the higheſt lands being upon the weſtern coaſts, this current preſerves its height, in paſſing over the low lands to the eaſtward, while low down, winds in various directions prevail by being under the eddy of the weſtern high land; as may be ſeen by different veſſels at ſea near the eaſtern coaſts, as well as different places upon land, not far diſtant from each other, from their having at the ſame time winds widely different from each other, while the higher clouds may be perceived by an attentive obſerver to move all the time uniformly and ſteadily to the eaſtward; from which circumſtance it appears, that the winds are more from the weſtward, and leſs variable upon the weſtern coaſts of Britain and Ireland, than they are upon the eaſtern.

Again, it ſometimes happens, with ſtrong gales of weſterly winds accompanied with heavy rain, falling upon the weſtern coaſts, that the rain by falling and carrying the Atmoſphere down with it, transfers its current to the ſurface, which burſting through between the mountains, ruſhes with great force down through the valleys to the eaſtward, in ſudden and ſtrong gales, while the clouds above appear almoſt ſtationary. Theſe gales are moſt prevalent in the autumn and fall of the year, and are peculiar to the eaſtern coaſts of Britain or Ireland, with weſt winds, and in other inland ſituations, with the wind blowing from off the mountainous parts; for in gales of wind blowing at ſea, or from off the ſea upon the land, the clouds moſt commonly accompany the wind with ſome velocity.—The commencement of theſe ſort of gales is always very ſudden, and from their blowing ſo low down, the condenſation of the lower Atmoſphere upon the European continent to the eaſtward, by the night cold, more effectually retards their progreſs, and thus commonly renders them moderate toward evening.

As the ſummer muſt commence before the cold in Ruſſia, Poland,

and the North of Germany will ſuffer a circulation in the lower region over theſe places to be carried on to the ſouthward, therefore the circulation which in the ſpring of the year commences to the caſtward, over the northern ſeas toward Greenland, by having no vent over theſe countries, muſt proceed to the ſouthward, along the Norwegian coaſts, and from thence forms the North and N. E. winds which are often hurtful to the bloſſoms, and at that ſeaſon are found ſo common upon the Eaſt coaſt of Britain, and neighbouring coaſts on the continent; from thence theſe winds, by proceeding down the Britiſh Channel, frequently continue to the S. W. along the coaſt of Portugal, till at laſt they join the trade-wind.—But when the froſt comes to be removed by the ſummer warmth, from off the continent of Europe, and the circulation up the White Sea and up the Baltic and rivers in Germany, comes from thence to be carried on to the ſouthward toward the Mediterranean, theſe North and N. E. winds become leſs frequent in Britain; and from the circulation to the eaſtward being ſtill continued in the Greenland ſeas, the weſterly winds do not commence ſo as to be prevalent; therefore the winds in Britain are variable, and ofttimes calms prevail during the months of June and July, until about Auguſt, when from the northern part of the American continent having received its greateſt warmth, and the cold beginning to incroach upon the North of Europe, the circulation from the eaſtward over the Greenland ſeas begins to ceaſe: It then returns to its common channel, North of the Weſtern Iſlands, and over Britain, and the weſterly winds commence; which by branching to the northward, after they are to the eaſtward of the Banks of Newfoundland, circulate round the North Cape at this ſeaſon, up the White Sea, and over Ruſſia and the reſt of Europe, to the Mediterranean.

Theſe weſterly winds, flowing in from off the Atlantic Ocean upon the Weſt of Europe, by proceeding up the Baltic, and up the valleys of the rivers in Germany, ſupply the deficiency cauſed by the prevailing Northerly winds that flow from off the northern ſhores upon the Mediterranean, where they are in great part drained from thence by ſea breezes upon the African coaſt bordering it, and there ſupply the drain carried to the weſtward by the trade-winds from off the African N. W. coaſt. Sometimes the northerly winds from off the northern coaſts of the Mediterraranean proceed in winds called *Levanters* to the weſtward, through the Straits, and over the South of Spain and North of Africa, for ſupplying the northern part of the trade-winds; and thus complete the circulation.

During the winter ſeaſon, the froſty maſs of Atmoſphere upon the North of Europe (in the ſame manner as that deſcribed upon N. America) is continually diffuſing itſelf by its ſuperior weight over the ſurface of the earth, toward where the Atmoſphere is warmer, thus ofttimes producing a N. E. or Eaſt wind from off the weſtern coaſt, along the ſurface of the ſea, in oppoſition to the general weſterly winds, and thus by its greater weight obliges the latter to float higher up, where proceeding to the eaſtward, it ſupplies, in the higher region, the deficiency cauſed by the flowing out of that below, whether to the weſtward upon the Atlantic, or to the ſouthward upon the Mediterranean. When moderate, theſe eaſterly winds from off the Weſt coaſts of Europe frequently do not reach ſo far as the coaſts of Britain, but may be known to prevail upon the ſea to the eaſtward, by the ſwell beating againſt its eaſtern ſhores; and when eaſterly ſtorms become ſo violent as to reach Britain, they frequently do not penetrate over the mountains to the Weſt coaſt, in ſo much, that there they often enjoy fine weather, while the ſtorm rages upon the Eaſt coaſt. From all theſe circumſtances it appears, that the eaſterly winds, which during the winter cold ſo frequently blow from off the Weſt coaſts of Europe, reach but a little way upon the ocean before they are overcome, or diverted into another direction, by the prevailing weſterly winds, or by mounting up they unite with the weſterly winds, and return with them in the higher regions, or elſe return in a circuitous direction by a different route, by which the general circulation is ſtill carried on, and ſupply furniſhed for the Atmoſphere flowing to the ſouthward upon the Mediterranean. It is true, the N. E. winds frequently continue down the Engliſh and St. George's Channel, acroſs the Bay of Biſcay to the ſouthward, but the Eaſt and S. E winds ſcarcely ever continue any diſtance upon the ocean, without having their direction changed.

To the ſouthward of Cape Finiſterre, the northerly and eaſterly winds begin to prevail, in order to ſupply the trade-winds, and the farther to the ſouthward, theſe winds become more prevalent, until among the Canary Iſlands, where they are fixed at N. E. and from thence called the trade-winds. As the trade-winds are conſtant, the ſupply for ſupporting them muſt be regular; but as the ſpace from whence this ſupply is derived, is of great extent, the particular ſpot for ſupply is often ſhifted, and therefore very uncertain; for inſtance, the ſupply may at one time come wholly from off the Mediterranean and North of Africa, in which caſe other winds, ſuch as Weſt or S. W. may prevail upon the ſeas round Madeira, and between that and Cape St. Vincents; and at another time it may come from off theſe ſeas, and ceaſe from off the Mediterranean. But it is moſt probable that the greateſt and moſt conſtant part of the ſupply for the northern trade-winds is from off the northern part of the continent of Africa, toward which it flows in ſea breezes from off the Mediterranean.

It hath already been obſerved, that in warm weather, the land imbibes more heat than the ſea, and retains more cold in cold weather; alſo that the heat the land receives during the day, diminiſhes conſiderably during the night; whereas the temperature of the ſea is nearly uniform at all times, and its difference as to climates not very great; from which circumſtance there will be an almoſt continual difference in temperature between the land and the ſea in every place upon the ſurface of the earth, which will cauſe a current of Atmoſphere to flow from one to the other, by the colder always moving toward the warmer. Thus in the equatorial climates, where the land during the day is warmer than the ſea, the ſea breeze as before deſcribed takes place, and in the cold climates near the Poles, where the land is colder than the ſea, the cold Atmoſphere ruſhes off as deſcribed, from the Eaſt coaſt of North America; only as the ſea breeze is ſtrongeſt during the heat of the day, ſo the cold winds that flow from off the land in the northern climates are ſtrongeſt during the night; but the cold upon the polar lands being more conſtant, (as they abate but little by the heat of the day) ſo the violence with which they blow is more uniform while they laſt. In the middle climates, between the extremes of heat and cold, where each only exiſts in a moderate degree, the effect of either ſea and land breeze are not ſo conſpicuous, on account of the difference of temperature not being ſo great, and of the general winds not being conſtant or uniform, in either their ſtrength or direction; yet during moderate weather they are perceptible, in ſo much, that the moſt ignorant ſailor, when coaſting along ſhore, knows that toward night the wind will come more from off the land, and draw more from the ſea during the heat of the day; not knowing that the cauſe of this change of the wind is the condenſation of the Atmoſphere by the night cold upon the land, which produces the land breeze, and its rarefaction by the heat of the day, which produces the ſea breeze. Alſo it is upon the ſame principle we generally perceive, that along the weſtern coaſts of Europe, the weſterly winds, though blowing ever ſo ſtrong during the day, commonly become moderate, or perhaps die away in a calm toward night, owing to the increaſe of cold upon the approach of night, which commencing upon the continent to the eaſtward, condenſes the Atmoſphere there, and retards or perhaps altogether obſtructs the further progreſs of the weſterly wind.

It is to be obſerved, that winds blowing angularly to the direction of a coaſt, are always led to proceed more in that direction, becauſe the elevation of the land ſerves as a bank to reſtrain and conduct it along it, in the ſame manner that wind blowing angularly upon a a valley, is by the ſides of the valley conducted along it. Therefore two ſhores of high lands meeting ſo as to form an angle in a cape or headland, a wind blowing off theſe ſhores will have its direction changed along with the ſhore on each ſide the cape, ſo as to be found ſome points of the compaſs on one ſide different from what it is on the other.

OF WATER,

AS IT EXISTS IN THE ATMOSPHERE:

Its Aſcent in Vapour, Condenſation into Clouds, and Precipitation in Rain, Hail, or Snow.—The Cauſe of Squalls, Tornadoes, and Hurricanes.—An Eſtimation of the Quantity of Water collected for ſupplying the great Rivers that riſe between the Tropics in SOUTH AMERICA.—*With the Effects the Aſcent of Vapour, its Condenſation and Precipitation, have upon the Winds and Weather on the North* ATLANTIC, *the Continents of* EUROPE, AFRICA, *and* NORTH AMERICA.

THE ſeparation of water, and its expanſion into vapour, ſo as to float in the air, is a ſubject which appears not to be as yet ſatisfactorily accounted for, notwithſtanding the many hypotheſes that have hitherto been advanced concerning it; therefore I ſhall ſay nothing about it here, but leave it to the diſcuſſion of thoſe of more ability, knowledge, and experience in philoſophy; and content myſelf with obſerving, that from the riſe of vapour, the quantity of water which floats in the air is ſo great as to form a conſiderable part of the Atmoſphere in the lower regions.

Vapour is found to riſe in all temperatures above freezing, and the greater the heat either in the water or moiſture from which it riſes, or in the air into which it aſcends, the greater will be the quantity that will riſe from the former, and will float in the latter. Now ſince it is found by experiments, that vapour riſes more plentiful in vacuo than in the open air, it may from thence be inferred that air is rather an impediment to its riſe; from which it appears, that it is by virtue of its own elaſticity received from the heat of either the water from whence it riſes, or of the air into which it aſcends communicated to the ſurface of the water, that it ſeparates, riſes, and expands, and being by this expanſion of leſs gravity than the air, floats in it; and if the air be of the ſame or of a greater degree of heat than the water from whence the vapour riſes, they unite and mix together, from a ready diſpoſition in each for that purpoſe, and become inviſible to the eye; but if the air be colder than the water, the vapour immediately upon emerſion condenſes and becomes viſible, as in the caſe of ſteam.

But whether by thus mixing and becoming inviſible, the water by diſſolving enters and lodges in the interſtices of the air, in the ſame manner as ſalt diſſolved in water does, thereby increaſing the weight without enlarging the dimenſions, or by keeping ſeparate, it increaſes the dimenſions of the maſs in proportion to the quantity added, I will not take upon me to determine; only I am rather inclined to the former opinion, namely, that the water reduced to vapour, by diſſolving in the Atmoſphere, increaſes its weight without materially enlarging its dimenſions; and that it is upon being ſeparated it becomes viſible in ſteam, fogs, clouds, &c. I am induced to be of this opinion, by obſerving, that the Atmoſphere, be it ever ſo warm, is heavieſt when clear; for it is well known, that vapour while tranſparent is generally lighter than the air it floats in, conſequently did it occupy a ſeparate ſpace, the maſs compoſed of both muſt be lighter than if wholly compoſed of air; alſo the maſs in a tranſparent ſtate would be lighter than when the vapour is condenſed into a cloud, or into fog, becauſe in the laſt ſtate it occupies a leſs ſpace; whereas the Atmoſphere is found in general to be lighteſt when hazy, foggy, or cloudy.

As vapour expands by heat quicker, and in a much greater degree than air, it hence follows, that the greater the heat, the greater will be the expanſion of the vapour above that of the air, and the greater the quantity of vapour that will float in it; therefore when a warm Atmoſphere is loaded with vapour, a colder degree of temperature taking place will condenſe the vapour quicker than the air, by which the former muſt ſeparate, becauſe of the air not being able to lodge or ſupport the ſame quantity in a cooler temperature; this circumſtance may be ſeen to take place, when upon emerſion the vapour is warmer than the air it riſes into; as in the caſe of ſteam, which upon riſing into a cooler air immediately condenſes, and becomes viſible; and if the air be of a warm evaporating temperature, the ſteam, after accommodating itſelf to that temperature, will diſſolve again, evaporate, and become inviſible. The ſame may frequently be obſerved of clouds from a cold climate when meeting with a warmer temperature, and of a morning fog when the ſun gets up, by their evaporating and becoming inviſible; alſo according to this theory it is very probable, that rain while falling through a warm temperature may loſe ſomething by evaporation; from which circumſtance it is poſſible, that a ſlight ſhower from a very high cloud, in warm weather, may all evaporate on its way down, ſo as none to reach the ſurface of the earth.

The condenſation of vapour is always too ſudden for the whole ſpace it occupies in its full expanſion to contract toward a centre, therefore its condenſation conſiſts of extremely ſmall ſpaces of the expanſion contracting and ſeparating from each other, and forming ſmall globules or maſſes, whoſe ſize is in proportion to the quantity of water contained in the contracted ſpace, and denſity to the degree of cold they are condenſed by; ſo that the greater the cold is, the more of the vapour contained in the contracting ſpace will be condenſed by it; therefore the warmer and the more replete with vapour the Atmoſphere is, and the greater and more ſudden the cold, the larger and denſer will the contracted globules be. From all which circumſtances it appears, that in Atmoſphere replete with vapour, the quantity condenſed is only according to the cold applied; ſo that after a firſt condenſation takes place, a greater degree of cold will produce a ſecond, and ſo on, until it arrive at a ſevere freezing temperature; after which it appears, that either no more water is left in the air, or elſe that no more will ſeparate from it by the common operations that take place in the Atmoſphere.

The ſmall globules thus formed by condenſation, appear to be ſurrounded by ſome repelling principle acting to extreme ſmall diſtances, by which they are preſerved from uniting by their gravitation into a maſs. Now as the electric fluid is found from experiments to abound in the Atmoſphere, and to be in greater plenty in clouds than elſewhere; therefore ſince clouds are compoſed of theſe globules formed of condenſed vapours as above deſcribed, and the electric fluid having a great propenſity for collecting about ſubſtances of that nature, it may be naturally ſuppoſed, that by collecting round each of theſe globules it forms this repelling force which keeps them ſeparate, and by its levity helps to ſupport them afloat in the Atmoſphere, which accounts for its greater abundance in a cloud than elſewhere; and we are more led to admit of this ſuppoſition, becauſe the appearances obſervable in clouds exactly correſpond with it. Thus the larger the globules are, the more electric fluid muſt be attached to them, in order to keep them afloat; and as the heavieſt clouds are compoſed of the largeſt globules, we therefore find that they always contain the greateſt quantity of electric fluid; ſo that when theſe globules are made to unite into drops, the electric fluid which ſurrounded them will in a great part be diſengaged, and collecting in quantities, (from having nothing to attach itſelf to), will be put in motion by its accumulation producing theſe unaccountable appearances of motion that we ſometimes ſee in clouds; and if the accumulation is great, it will become more active, producing thunder with its lightning, &c.

The electric fluid ſurrounding theſe globules, will no doubt help to preſerve them from the froſt, when it is only in a ſlight degree; for it is evident that water, in a fluid ſtate, floats in the Atmoſphere in clouds at the time it is freezing upon the ground. No doubt this, in ſome circumſtances, may be occaſioned by the Atmoſphere at that height retaining a ſufficiency of warmth to keep the clouds from congelation, while the denſe froſty Atmoſphere below is extending itſelf along the ſurface of the earth, by its ſuperior weight carrying its freezing qualities along with it. Indeed a cloud of great elevation being congealed to ſnow, may, from the ſlowneſs of its deſcent, float a conſiderable time before it falls to the ground. But that water will float in a fluid ſtate in the Atmoſphere, in a temperature that freezes it upon the ground, may be ſeen in what are called froſty fogs, as they often happen upon moraſſes and collections of freſh water, particularly if ſhallow. I have ſeen theſe froſty fogs upon the ſhallows about the mouth of the Thames, and obſerved that the globules adhered and froze upon any ſubſtance the inſtant they touched it; in ſo much, that a ſhip lying ſtill at anchor would have her rigging in a ſhort time loaded with ice, by theſe globules adhering and freezing upon it. Now it is evident that theſe globules muſt be in a fluid ſtate while floating, becauſe of their adherence upon touching; for were they froze into ice, they could not adhere, but muſt tumble and fall the moment they touch any ſubſtance

It no doubt may be aſked, that as water floats in the air, why may it not float in a frozen as well as in a fluid ſtate, as the former inſtead of condenſing rather enlarges its dimenſions? to which it may be anſwered, that the dimenſions or ſpace occupied by water in globules while in a fluid ſtate, cannot be aſcertained from what is yet known concerning them; therefore for ought we know, they may be hollow or otherwiſe dilated ſo as to enlarge their dimenſions; neither is it known what ſize or form they might aſſume in a frozen ſtate. But all theſe conjectures will be rendered uſeleſs, if we ſuppoſe, that upon the globules being froze, the electric fluid withdraws its ſupport, and leaves them to fall. However, be all theſe as they may, no obſervation or experiment hath yet, as I believe, found water in a frozen ſtate ſuſpended in the Atmoſphere; and what further leads to this ſuppoſition is, that the Atmoſphere is found continually parting with its water by every increaſe of cold, until in the polar climates, where intenſe froſt having continual poſſeſſion, no clouds or vapour is ever to be ſeen, conſequently no fall of watery ſubſtance out of the Atmoſphere takes place. It is impoſſible for water diffuſed the ſame as when in vapour to float in a froſty Atmoſphere, becauſe of the froſt depriving it of its elaſticity; and if when floating in frozen globules it be imagined that the tranſparency of ice renders it inviſible, ſurely water is as tranſparent in a fluid as in a frozen ſtate; therefore ſhould any quantity of it float in a frozen ſtate, it muſt collect in maſſes by the gravitation of its parts, in the manner it does in clouds when in a fluid ſtate, and become viſible by either obſcuring, refracting, or reflecting the light in the manner clouds do.

As an inſtance of the dryneſs of a frozen Atmoſphere, I have been told by people who have reſided in frozen countries, that during intenſe froſt, the Atmoſphere, by the leaſt warmth, ſucks the moiſture out of the floors and furniture of the houſes, leaving them as parched as if expoſed to the moſt drying wind in the heat of ſummer; and we know from daily obſervation, that the winds from a cold climate are thoſe of a moſt drying nature. Indeed the dryneſs of the Atmoſphere may not be ſo eaſily perceived in frozen countries, becauſe the preſence of any living creature always carries warmth along with it, and the leaſt warmth, by thawing, always produces moiſture; and to this circumſtance it perhaps may be owing that the idea of the evaporation of ice is propagated; and even admitting that ice may loſe by evaporation, any moiſture raiſed by the extreme thirſtineſs of the froſty Atmoſphere is immediately let fall again, as may be ſeen by a froſty wind blowing ſtrong from the land upon the ſurface of the ſea near it, or other water while in a fluid ſtate, by the aſtoniſhing evaporation it produces, which by condenſing the inſtant it emerges from the water, becomes viſible, and reſembles ſteam riſing from a boiling caldron; but the Atmoſphere being too cold to retain this evaporation, it immediately upon condenſing falls down in drops, and freezes the inſtant it touches any ſubſtance, ſo that none of it remains in the Atmoſphere while in a frozen ſtate.

From what hath been ſaid it will readily appear, that it is only from heat that water is converted into vapour, receives its elaſticity, mixes with and diſſolves in the air; and although it may be ſaid to be ſeparated from the air when in haze clouds or fogs, and in that ſtate is enabled to float by the help of the electric fluid or ſome other principle, ſo long as it is in a fluid ſtate, yet upon being froze, the whole of it finally ſeparates from, and by falling, quits the air altogether, nor can it exiſt in it while in a frozen ſtate, unleſs it be ſuppoſed that a ſmall portion in form of exhalation may float in particles ſo very ſmall, few, and ſeparated, as to have no ſenſible gravitation ſo as to collect in maſſes; and from theſe circumſtances it can only be within the temperate regions that water exiſts, and forms part of the Atmoſphere, being there deſigned by the great AUTHOR OF NATURE for the ſupport and comfort of animal and vegetable life; ſo that the far greater part of the Atmoſphere lying without the temperate regions, by being in a perpetual frozen ſtate, hath no uſe for water, and is therefore deſtitute of it.

As vapour ſeparates and riſes from water more by the elaſticity it receives from the heat, than by any attraction of the air, (eſpecially if the air is already ſaturated with it to any conſiderable degree) it will therefore in warm and ſtill weather, by continually endeavouring to riſe faſter than the air will receive it, be found in great abundance upon the ſurface of water, moraſſes, and wet places, reſting upon the ſurface, ſupported and lying expanded by its own elaſticity, and from more vapour continually endeavouring to riſe together, with the weight of that which is already up, and not ſupported by the air, it becomes of greater denſity than the Atmoſphere over it, ſo that objects ſeen through it are by its refraction made to appear higher than they really are, and often with their ſhape altered and diſtorted by an undulating motion cauſed by the vibrating motion ariſing from the great elaſticity of the expanded vapour, thereby having in the whole that curious appearance which ſailors call *looming*. (The reflection of land, houſes, trees, &c. by the gloſſy ſurface of the water under them, as ſeen in calm and ſtill weather, is likewiſe often called looming, but the former are thoſe appearances which properly come under that appellation). Theſe looming appearances are often ſeen upon woods where there is bruſhwood, or whatever retains moiſture, but ſeldom in dry barren places, and never in froſty weather, unleſs the froſt be very ſlight indeed; alſo a heavy ſhower always diſperſes theſe looming appearances, by carrying the vapour thus reſting upon the ſurface down with it, which accounts for the rain-gages near the ground collecting more water than thoſe placed at any conſiderable height above it.

When in the above manner the vapour has accumulated over any place, it will retard the riſe of more by its preſſure, and the want of room for more when riſing to expand; and this hindrance to the riſe of more vapour will continue until a breeze of wind ſweeps away the incumbent maſs, after which more will riſe in great plenty till again retarded by accumulation; hence we ſee the reaſon of things drying ſo much ſooner where there is a breeze of wind, than they do in a calm, becauſe the wind by continually ſweeping away the vapour as it riſes, leaves room for more to riſe immediately after, and there is no doubt but it is part of this accumulated vapour reſting upon the ſurface by being condenſed by the night cold, and falling upon the ground, which forms the dew, and when the cold is intenſe enough to freeze it upon falling, it then becomes hoar froſt.

Here it may not be improper to remark, that in the fall of the year, when hoar froſt firſt commences, that it is always obſerved to take place nearly about the ſame time at the bottom of the vallies, and upon the ſide of the mountains, whereas ſnow upon falling will often lie upon the tops and ſides of the mountains, down to a line of equal elevation, below which it melts and falls in rain, by the greater warmth of the lower Atmoſphere in the valleys. Now if freezing took place only according to the cold in the Atmoſphere, the hoar froſt would firſt take place upon the tops of the hills, and like the ſnow, would at times be found only upon the tops and ſides of the mountains, down to a certain elevation, while the valleys would be free from it. That from the greater cold in the Atmoſphere the high lands are firſt affected by froſt, is not to be denied, only the diſtinction is not ſo viſible as the difference in temperature would lead us to ſuppoſe, which muſt be owing either to a greater diſpoſition in water toward freezing, when touching any ſolid ſubſtance, than it has while floating in the air, or elſe (what hath already been advanced, and which I think moſt probable) to the water being preſerved from freezing by the electric fluid, or ſome other ſubtle quality attached to it while afloat on the air, which by quitting it upon touching any ſolid ſubſtance, leaves it to the full effect of the cold.

As to the looming appearances above-mentioned, I have remarked, that they are greater upon the coaſts of North America than they are upon the coaſts of Europe, which is no doubt owing to the land in the former being ſo much covered with woods, which preſerve the ground moiſt, and by being a low country, it is interſperſed with ſwamps and rivers. Alſo the banks or ſhoals in the ſea along this coaſt, exhibit theſe looming appearances more than banks of the ſame nature and depths do upon the coaſt of Europe, which together with the frequent fogs upon them, muſt be cauſed by the great quantity of vapour riſing from the gulf ſtream, flowing along their outer edges, on account of its greater warmth, and carried from thence by ſoutherly winds to the northward upon theſe banks, where it is condenſed by the greater cold there; for it is obſervable, that the gulf ſtream and ocean to the ſouthward of it, is (from the water of them flowing from the Weſt India ſeas) warmer than the ſeas upon the European coaſts; and the water upon the Nova Scotia and Newfoundland banks are colder than the European ſeas, becauſe it flows from the Greenland ſeas, as appears by the quantities of ice carried yearly to the ſouthward by it. Theſe looming appearances when ſeen by mariners, are a ſure ſign of being upon ſoundings, or near it, as they never appear in the deep ocean.

As cold is the principal cauſe of the condenſation of vapour, it hence follows, that vapour is condenſed into clouds on aſcending into a higher region; becauſe of the increaſe of cold there, and the more vapour that floats in the air, the leſs cold is required to condenſe it; ſo that in this laſt caſe, the clouds will be formed lower down: alſo the condenſation will be accelerated in the higher regions, by the decreaſe of denſity there; becauſe the leſs denſe the air is, the leſs vapour it will ſuſtain. From theſe circumſtances, the vapours will riſe higher in the equatorial climates before it condenſes, than it will in the climates toward the Poles; becauſe in the firſt place, the heat riſes to a greater height for keeping the vapour ſuſpended in it; and in the ſecond place, from this greater heat the denſity decreaſes in a leſs proportion according to the altitude, and thus will be able to ſupport the vapour at a greater height, ſo that the clouds float higher there, and occupy more perpendicular ſpace, than they do in the cold climates.

Vapour is alſo condenſed by the increaſe of cold on moving from the equatorial toward the Polar climates. This increaſe of cold may be ſaid to begin at the Tropics; and without the Tropic of Cancer, the vapour carried to the northward by a ſoutherly wind on its firſt beginning to condenſe, may be perceived in the higher region by appearing in a white haze, and as the condenſation goes on, it gradually darkens and deſcends until it become a denſe heavy cloud, which in a ſhort time generally diſcharges itſelf in rain. Should any ſmall clouds from another direction meet or join this condenſation while it is taking place, they commonly evaporate and diſappear in the condenſing maſs. As theſe condenſations of vapours moving from the equatorial to the Polar regions, take place every where without the Tropic to where the froſt has poſſeſſion of the Atmoſphere; and as no condenſation is ever ſeen to take place, or clouds to form in the froſt, it is evident that, (as before mentioned), the air parts with the water contained in it, only in proportion as the cold increaſes, until it arrives at an eſtabliſhed froſt, in which ſtate the air is deprived of nearly, if not all its water.

When treating of the cauſe of winds, it was ſhewn that it is near the ſurface of the earth, underneath the ſun's perpendicular rays, where the Atmoſphere receives its greateſt heat, and by being moſt rarefied there, it is forced in a continual ſtream upwards, by that which is cooler and denſer flowing in from the lateral parts by its ſuperior weight, and forcing the lighter, by floating higher, to give it place. Now the Atmoſphere, thus flowing in from the lateral

teral parts, being loaded with vapour, which being rarefied by the ſun's warmth, and more vapour continually riſing, and the whole being forced into a higher region, by more denſe Atmoſphere flowing in below, the vapour which is thus forced up, upon coming into a colder region, will condenſe much quicker than the air, and become too heavy to float in it. Thus ſeparating, it will deſcend in condenſed globules forming a cloud, which muſt accumulate by the addition of more globules continually left condenſed by the aſcending air, until they become too numerous for the ſpace, and too heavy for the air to ſupport; therefore, by crouding together, and from the internal motion incident to the whole proceſs, ſome of them will be forced ſo near each other, that, overcoming the repelling property which kept them ſeparate, they will joſtle and unite; forming drops, whoſe weight being increaſed in a much greater proportion than their ſuperficial dimenſions, they will deſcend; and in their deſcent ſtrike againſt, and unite with more globules coming in their way as they paſs down through the cloud, thus increaſing as they deſcend. Theſe drops falling, will communicate motion to the air through which they fall, which will cauſe more globules to joſtle, unite, and form drops; and they in like manner others, and ſo on, until, by increaſing the number, the ſhower become general, which continuing, will ſoon exhauſt the cloud—this will produce a rarefaction in the Atmoſphere; firſt, by its expanding to fill up the ſpace the cloud occupied, and again, from the removal of the weight of water deſcended in the ſhower; which rarefication will cauſe more vapour to condenſe, and from the motion already excited, this laſt condenſation will coaleſce in drops, and they again falling, will prolong the ſhower. Thus we ſee that a ſhower once begun, may be prolonged beyond the ſupply at firſt contained in the cloud, from the condenſation of more vapour joining and continuing it, eſpecially if the temperature is not very cold, and the air replete with vapour. Hence we ſee the cauſe that between the Tropics the rainy ſeaſon always takes place where the ſun is vertical.

As it is by the globules uniting and forming into drops, which become too heavy for the air to float, that a cloud precipitates in rain, it hence follows, that every circumſtance or motion that is ſufficient to overcome the repulſion, and cauſe the globules to unite, will have this effect, by producing drops which muſt deſcend by their weight.

Thus we ſee, that the line of a fiſhing rod, making a ſweep through a denſe watery fog, will, by daſhing the globules together, produce drops that may be ſeen falling upon the water; alſo, a denſe fog being carried by a breeze of wind through the branches of a tree, the rigging of a ſhip, or meeting with any other obſtruction which from commotion the globules may be made to joſtle and unite, will produce drops. In like manner, when clouds are toſſed about by irregular or adverſe winds, although they may not be very denſe, yet their globules, or at leaſt many of them, will be daſhed together and fall in drops; from which it appears, that it is only the clouds that are leaſt diſturbed, and have time to increaſe in denſity and perpendicular dimenſions, that fall in the heavieſt ſhowers; and thoſe that are toſſed about by the wind, fall in light but frequent ſhowers.—Alſo the electric fluid by its motion is no doubt frequently the cauſe of rain, and the ſheets of water that are ſometimes ſeen to fall ſuddenly from thunder clouds, may be cauſed by the lightning darting through it, and daſhing together in a maſs great quantities of the globules.

But the froſt may be accounted the laſt cauſe of the precipitation of a cloud, by the ſupport which floats the globules in the air, leaving them immediately upon being frozen; this muſt happen either in the upper regions, or upon approaching the polar cold; in the laſt caſe the clouds are frequently converted to drops by the great agitation of the Atmoſphere, which generally takes place between the temperate and frozen regions, and being frozen upon deſcending through a colder region below, fall in hail; but if the cloud is frozen before the drops are formed, they fall in flakes of ſnow; from all which circumſtances it may be ſeen, that the precipitation of clouds depends either on the decreaſe of denſity in the Atmoſphere, the increaſe of cold, together with the quantity of internal motion, and what is perhaps moſt common, a combination of theſe.

Clouds always appear in maſſes of greater or leſs magnitude, by the gravitation of their parts, and are ſeparated or daſhed together in various forms and poſitions, by the force and violence of winds, or other accidental cauſes.—That clouds have a conſiderable degree of attraction by gravitation, is viſible, by their adhering to the tops of mountains, for I have frequently obſerved a cloud attracted by a mountain, ſo as to deſcend from a conſiderable height and reſt upon its ſummit. Indeed it may be generally obſerved, that no cloud will paſs near a mountain without the whole or a part of it being drawn toward it by attraction.

During calm and warm weather, with the ſky interſperſed with ſhowery detached clouds, I have frequently, and with a great deal of attention, obſerved theſe clouds when lying in a horizontal direction where I could beſt ſee their perpendicular dimenſions, while condenſing and falling in rain; clouds of this deſcription commonly have their lower parts dark and of a denſe appearance, which, in addition to their being compoſed of the heavieſt globules, is no doubt owing to their being ſhaded from the ſun's rays by the upper parts; which upper parts, by the ſun's ſhining upon them, appear bright and luminous in volumes towering over each other. When about to diſcharge itſelf in rain, the cloud increaſes its perpendicular dimenſions by an internal motion of ſeemingly the heavieſt globules or particles deſcending and leaving the lighteſt behind, thus lengthening downward until it arrive at a certain height, where it begins to form a denſe dark baſe, and as this baſe forms, the ſhower is ſeen beginning to deſcend through it, increaſing in quantity as the baſe does in ſize. While the ſhower is falling, the particles or globules compoſing the upper part of the cloud, may, to appearance, be diſtinctly ſeen deſcending, the heavieſt firſt, through the reſt of the cloud to the baſe; thus the cloud gradually vaniſhes, the upper part firſt, until nearly or altogether exhauſted; and if any remain after the ſhower ceaſes, (which is often the caſe in warm climates) it immediately aſcends higher in the Atmoſphere. During the whole time the cloud is diſſolving, and the ſhower falling, the baſe continues at the ſame elevation, unleſs agitated by wind, and frequently we ſee fragments from it deſcend, to appearance, as if ſeparated and forced down by the impetuoſity of ſome part of the ſhower. From the addition the drops are continually receiving by the globules uniting as they deſcend, it will readily appear, that the more the cloud is in perpendicular dimenſions, the larger will the drops that compoſe the ſhower be, from the greater quantity of globules that will unite; therefore we find, that the heavieſt ſhowers containing the largeſt drops fall in the warmeſt climates, becauſe not only the clouds being compoſed of larger globules, from the greater quantity of vapour floating there, but alſo the temperate warmth riſing to a greater height, the clouds from thence have greater perpendicular dimenſions.

It is well known, that the vanes of a winnowing machine, or any other body or bodies, moving with any degree of velocity through the Atmoſphere, generate a motion in it, by forcing along with them thoſe parts of the Atmoſphere they diſplace, or that comes in contact with them; therefore a drop of water falling with any degree of velocity, generates a motion downwards in that part of the Atmoſphere through which it falls, and a number of theſe drops falling together from a conſiderable height, muſt cauſe a motion downward in the Atmoſphere, in proportion to the number and velocity with which they fall; hence we ſee, that a ſhower (be it ever ſo ſlight) falling upon the ſurface of the ſea in calm weather, produces a breeze of wind upon that part of the ſurface on which it falls, which is evidently occaſioned by the Atmoſphere carried down by the deſcent of the drops preſſing againſt the ſurface of the water, from which the lower Atmoſphere is put in motion to eſcape in a horizontal direction from that preſſure. Theſe breezes produced by the falling of ſhowers are by ſailors termed *ſqualls*, and their violence is in proportion to the extent and greatneſs of the ſhower, the ſize of the drops that compoſe it, and the perpendicular height from which they deſcend; hence we ſee that ſqualls, tornadoes, and hurricanes, are greateſt where the weather is warmeſt, becauſe (as hath been obſerved) it is there the heavieſt ſhowers fall from the greateſt height.

When a ſhower and the ſquall produced by it happen where there is a breeze of wind, the wind produced by them is a compound of both. Thus, if the breeze and ſquall are of equal ſtrength, the wind to leeward of the ſhower, by being the united forces of both the ſquall and breeze, will be double what the breeze was before, and that to windward of the ſhower, being their difference, from their forces being equal, will be a calm, and upon the ſides of the ſhower, at right angles with the breeze, the wind will be increaſed, and its direction altered ſome points of the compaſs from the ſhower. A ſhower of hail will have the ſame effect in producing a ſquall as a ſhower of rain, but ſnow, from the great extent of ſurface not allowing it to deſcend but with a ſlow motion, never produces a ſquall of any violence.

Upon the land, the compreſſed Atmoſphere carried down by a ſhower cannot ruſh out and diffuſe itſelf with the ſame facility as upon the ſmooth ſurface of the ſea, becauſe of the ruggedneſs and inequality of the ſurface; for which reaſon a ſlight or moderate ſhower may not produce a ſquall; but when by the violence of a ſhower a ſquall is produced, from its being generally forced along ſome valley, or down ſome declivity by the reſiſtance it meets from the adjacent hills and high lands, it will be more violent and partial than thoſe of equal magnitude are upon the ſea.

When a cloud of conſiderable magnitude and extent is diſcharging and falling in rain upon the ſurface of the earth, the vacancy cauſed by the Atmoſphere carried down by the ſhower, and the waſting of the cloud, will be filled up by the ſurrounding Atmoſphere moving into the place of that carried down, of which the upper air, by ſinking down, will form a conſiderable if not the greater part, and the cold of this upper air deſcending with it, will condenſe the vapour carried in along with the lateral parts, as well as what vapour may remain uncondenſed; and thus by adding to the diſcharging cloud, prolong the ſhower, by which means the greateſt part, or nearly the whole (in proportion to the degree of cold) of the vapour in the ſpace occupied by the cloud, and near it, will be condenſed and precipitated; hence in cold climates, from the deſcending air being of a freezing cold, we generally ſee, that immediately after a fall of rain, from the vapour being all condenſed and precipitated, the ſky becomes clear, eſpecially toward night, becauſe of the increaſe of cold then, which is ſometimes ſo great as to produce a hoar froſt upon the ground. It will be naturally aſked, why this deſcending cold, from its being of a freezing temperature, does not congeal the cloud into ſnow or hail? to which it may be anſwered, that the electric fluid, by quitting the water juſt before it is congealed, or upon its beginning to congeal, leaves it to deſcend, conſequently by deſcending quicker than the cold, it is preſerved fluid, and falls in rain; from this circumſtance, as well as from the evaporation which is ſeen riſing into a froſty Atmoſphere, (as formerly deſcribed) not being froze until it falls, it would appear, that a cloud is not froze by cold deſcending upon it, but by the cold attacking it from below, of ſuch intenſity, that the electric fluid is not able to preſerve the globules from freezing, while deſcending through it.

After the deſcent of the ſhower, the warmth of the neighbouring Atmoſphere will, by diffuſing, communicate itſelf to this deſcended air, which by being in a great meaſure, or perhaps altogether deſtitute of vapour, will receive the vapour from the lateral warmer regions, which by diffuſion will immediately flow in to reſtore the equilibrium, upon the ſame principle that ſalt melting will diffuſe itſelf through water, or that a ſcent diffuſes itſelf through a room; and thus when this air is ſaturated with vapour equal to that around it, the greater cold which may ſtill remain will tend to condenſe it into a cloud, which, by the internal motion incident to theſe proceſſes, will precipitate in rain, and thus theſe operations will commence again, and continue while there is an abundant influx of vapour to carry them on; hence when rain commences in great quantities in any particular place, we ſee the reaſon that it generally continues through intervals, until by a ſhift of wind or change of ſeaſon it is led to ceaſe, and from the continual deſcent of the higher air to replace that carried down by the ſhower, we ſee the cauſe of a rainy ſeaſon being always a cold one.

In the equatorial climates, as well as in warm weather in other countries, where the ſea breeze blows in upon the land, the vapour carried in by this breeze being forced by the riſing of the land into a higher and colder region, may be ſeen condenſed in a heavy cloud accumulating during the day by the continual influx of more vapour, which by imbibing the ſun's rays with their warmth, will by expanding, keep it afloat until evening, when by the temperature becoming colder, from the ſun's influence withdrawing, the parts of the cloud contract, and by becoming too denſe to float, they deſcend, and uniting in drops fall in a ſhower with a velocity proportionate to their ſize, and the elevation from which they fall, producing a ſquall or tornado, whoſe force will be accordingly; thus we ſee ſhowers producing ſqualls or tornadoes to be common on all ſea coaſts where ſea breezes are, and that they commence upon the increaſe of the evening cold, continuing from thence until the vapour is exhauſted, through the firſt or perhaps the greateſt part of the night, and that the fore part of the day until the rain commence again in the afternoon, is always the faireſt part of it; indeed in all countries, the greateſt part of the rain that falls with very warm weather, is during the afternoon and the night, particularly where the ſummer nights are of any length.

Although in warm climates the accumulation of clouds is very rapid during the day, becauſe of the great evaporation; and they gather in moſt abundance upon the land, becauſe of the greater heat there, yet, from the great increaſe of cold that takes place at night, the moſt part of the clouds (eſpecially if there is any great accumulation) are then diſcharged in rain; therefore accumulations of clouds ſeldom arrive at an alarming height upon the land. Upon the ſea, the conſtant wind or motion which is promoted in the Atmoſphere by the leaſt agitation, becauſe of the evenneſs of its ſurface, for the moſt part hinders an accumulation of vapour from gathering in one place; but where the Atmoſphere may chance to become ſtill for any conſiderable time, the vapour will continue to accumulate for days together, from the great equality there is in the temperature between the day and night, ſo that becoming of conſiderable magnitude, and a condenſation taking place, the ſquall will be more furious and of longer duration. Squalls of this deſcription ſometimes take place in the months of July, Auguſt, and September, from accumulations of vapour gathered by long calms near the northern limits of the trade-winds, and among the northernmoſt of the Weſt India Iſlands; but the moſt deſtructive and tremendous phœnomena of this kind, are the hurricanes which ſometimes happen in theſe months among the Weſt India Iſlands, and which may be accounted for as follows:——

The ſummer heat upon the ſouthern parts of the continent of North America continuing to increaſe until July, in which month, and during thoſe of Auguſt and September, it will be little inferior to the heat between the Tropics, ſo that the Atmoſphere will be nearly as much rarefied, and the column almoſt equally exalted with that to the ſouthward, which muſt hinder the circulation to the northward, which in the winter ſeaſon was carried on from off the Caribbean ſea and Bay of Mexico; therefore this circulation being obſtructed, and the Caribbean ſea fenced in upon the South and Weſt ſides by ranges of immenſe high mountains, which prevent any paſſage for the lower Atmoſphere that way, the continual influx of vapour by the trade-wind from the eaſtward, together with what riſes by the great heat of the climate, muſt produce a very great accumulation of it all over the Caribbean ſea, the Bay of Mexico, and the adjacent coaſts.

Now although the ſlow motion of the Atmoſphere to the northward over the continent of North America, and the North Atlantic Ocean, no doubt carries ſome of this accumulated vapour away with it, yet the far greater part will ſtill remain, which, together with the want of ſufficient vent for the circulation to the northward, will make the influx of the trade-winds to become ſlow and languid, ſo that from becoming languid, theſe winds will reach to a leſs height than ordinary, and by thus leaving the Atmoſphere over them calm, it will be enabled to receive and retain a greater quantity of vapour ſuſpended in it, which by intercepting the ſun's rays, will imbibe a conſiderable degree of heat, enabling it to ſuſpend ſtill more vapour; this heat will evaporate the clouds that before reſted upon the tops of the mountains, becauſe of the trade breeze which before kept them cool now not reaching ſo high, and thus the whole, from the expanſion it receives by the heat, will remain nearly in a tranſparent ſtate.

This proceſs of accumulation is beſt enabled to be carried on under the lee of ſome of the iſlands, particularly the circular chain of the windward Weſt India Iſlands, which by retarding or altogether obſtructing the feeble remains of the trade-winds, leaves the accumulation of vapour to proceed undiſturbed, and the heat increaſing by the calm, the vapour by riſing will force itſelf up into the Atmoſphere, and being too abundant to float, will reſt upon the ſurface expanded by its elaſticity, and if no partial condenſation takes place to carry it off, the whole of this proceſs of accumulation may continue ſome days, becauſe of little or no difference in temperature between day and night taking place at a very little diſtance above the ſurface of the ſea; after which the leaſt alteration by decreaſe of denſity or increaſe of cold, will produce a condenſation of this accumulated vapour, now become almoſt too abundant to reſt expanded in the Atmoſphere, which once begun, a precipitation will immediately take place, which, from the rarefaction produced by it, will cauſe the condenſation to ſpread rapidly, and thus a general condenſation and fall of rain will commence through the whole ſpace, and the immenſe quantity and weight of water produced by this condenſation being ſpread over a great extent of ſurface, and deſcending from a great height, will acquire a great velocity downward, carrying with it the air intermixed with and lying in its way, which by preſſing down the lower Atmoſphere upon the ſurface of the earth, will, by ſqueezing, oblige it to ruſh out to eſcape toward where it can eaſieſt find vent, and by its great force in ruſhing out, blow down, tear away, and deſtroy every thing in its way.

After a firſt condenſation, the rarefaction cauſed by the void left from the condenſation of the vapour and air carried down by it, together with the cold of the higher air deſcending to fill up this void, and the motion excited by the whole, will condenſe and precipitate what vapour remains, together with what flows in from the lateral parts to reſtore the equilibrium; thus a ſucceſſion of condenſations and precipitations will take place, ſo long as there is any vapour flowing in from the neighbouring regions to the general vortex; after which the trade-wind will reſume its direction, and flow in briſkly to fill up the vacancy, and the weather ſettle. The cold of the higher air which ſinks down to fill the void cauſed by the firſt condenſation, being by ſucceeding precipitations carried down to the ſurface of the earth, accounts for the cold which is always found to prevail immediately after hurricanes, tornadoes, and heavy falls of rain.

Since a hurricane is the ſqueezing out of the lower Atmoſphere along the ſurface of the earth, by the extraordinary preſſure of the deſcending water and higher Atmoſphere upon it, we may eaſily ſee the reaſon why little or no ſhelter is ever found from valleys or ſides of mountains, however ſituated, becauſe from the preſſure the air is by its elaſticity forced to ruſh through every hollow or other place in whatever direction. And this great preſſure which produces the hurricane will be the leſs ſurprizing, if we conſider the quantity of water that deſcends through the Atmoſphere in a common ſquall, much leſs in a hurricane, a quantity which is aſtoniſhing to think how the Atmoſphere could ſuſpend or ſupport, and beſides the quantity, if we conſider the velocity it muſt acquire upon deſcending perhaps upwards of a mile in perpendicular height, our ſurprize of the preſſure will be ſtill leſs.

Although accumulations of vapour gather more frequently upon the land than they do upon the ſea, yet they are never found to arrive to ſuch a height as to produce hurricanes ſimilar to thoſe deſcribed above; and if the land is mountainous, the accumulations are the ſooner diſperſed, becauſe the winds during the heat of the day carrying the vapour up the ſides of the mountains, it is there condenſed by the higher cold, and falls in rain; and even ſhould it be calm for any conſiderable time, the great difference there is in the temperature between the day and night upon the land, will, by the cold in the latter, diſturb and condenſe the expanſion and evaporation produced by the greater heat of the former, before an accumulation become too great; for which reaſon we find, that although ſqualls commonly happen upon the South ſhores of the Caribbean ſea, yet the hurricanes which are ſometimes ſo deſtructive among the Weſt India Iſlands, never come with violence upon the adjoining continent of S. America, on account of the accumulations of vapour being commonly condenſed and precipitated in rain by the night colds there; hence from the accumulations of vapour which at the hurricane ſeaſons take place upon theſe ſeas and their adjacent coaſts, as above deſcribed, by being continually condenſed and precipitated by the night colds and elevation of the land, is the cauſe of the almoſt continual deluge of rain that is found to take place upon the ſouthern coaſts of the Caribbean ſea and bays to the weſtward of it, and which renders theſe countries (particularly to the weſtward) ſo very unhealthy at this ſeaſon.

The circumſtance of the night colds condenſing the accumulated vapour upon the continent of America, and thereby preventing hurricanes taking place there, would hold good among the ſmaller Weſt India Iſlands, were they of ſufficient magnitude to allow night condenſations taking effect, and not ſurrounded by ſea, and from their being ſo ſmall, and lying in the midſt of the ocean, the continual ſhift of Atmoſphere by the trade-winds preſerves the ſame temperature upon theſe iſlands that is upon the ſea, which hinders accumulations of vapour from gathering upon them while theſe winds continue to blow with any degree of briſkneſs; but upon the trade-winds failing, and ſituated as they are in a circular chain, circumſcribing the ſea to the weſtward of them, great part of the cauſes that produce hurricanes may be attributed to theſe iſlands, from their obſtructing the trade-winds, and thereby producing a calm to leeward of them, which thus protects the vapour from being diſturbed while accumulating, until the accumulation arrives at the alarming height ſo as to produce a hurricane. From the extent of the larger iſlands of Jamaica, St. Domingo, and Cuba, it does not appear that hurricanes are violent in their interior parts, particularly among the mountains, although the hurricanes generated upon the neighbouring ſea frequently beat againſt their ſhores, and by their fury no doubt penetrate ſome diſtance in-land; alſo, from the theory advanced here, hurricanes ought not to be ſo violent upon the tops of mountains as they are upon the plains below, and every obſervation I could have an opportunity of making confirms this circumſtance.

The quantity of vapour carried from off the ſea and precipitated upon the land, is meaſured by the quantity of water diſcharged in rivers, brooks, runs, or otherwiſe, from the land into the ſea; but from the impoſſibility of aſcertaining this quantity, together with what falls in rain upon the ſea, renders it altogether impoſſible to aſcertain the whole quantity of vapour riſing from the ſea. Numbers of experiments have been made upon the riſe of vapour, but very little certainty hath been gained upon this ſubject, on account of its being ſo extremely various, according to times, ſeaſons, and ſituations. This is viſible by obſerving the drying of clothes or other ſubſtances; from which it is evident, that evaporation is very irregular, for it is well known, that drought (or evaporation) is greater in the day than in the night, in the ſummer than in the winter; and that it is ſcarcely found to be alike in any two of the ſame times or ſeaſons, independent of the difference which muſt neceſſarily ariſe from climates, expoſure, &c.

The learned Dr. Hally, from his experiments upon evaporation, calculates, that water ſalted to an equal degree with ſea water evaporated during the ſummer months in England, at the rate of about 1-5th of an inch per day; now it is generally agreed by thoſe converſant in this ſubject, that in England the evaporation during the months of May, June, July, and Auguſt, is one half of the evaporation in the year; September, October, March, and April, one third, and the other ſixth in the months of November, December, January, and February, from which eſtimate the evaporation in England, according to Dr. Hally, will amount to 48 inches in the year.

In the proſecution of the following ſubject, it is found neceſſary that a certain rate of evaporation be adopted as a ſtandard, for the greater facility of inveſtigating and explaining the particulars contained in it; therefore I ſhall adopt that of Dr. Hally, leaving its accuracy to be aſcertained by future obſervations. Now the Doctor's computation being one-fifth of an inch of evaporation per day, during the ſummer months in England, if the reſt of the year was of the ſame temperature, its whole evaporation would amount to 73 inches. But the weather between the Tropics is conſiderably warmer than the ſummer in England, and they who are acquainted with thoſe climates, know that the evaporation there is far greater, and the trade-winds continually blowing, muſt add conſiderably to it, ſo that eſtimating the evaporation from the ſea between the Tropics at one-fourth of an inch per day, or 91 inches in the year, will by no means be found too little; and indeed from what I have obſerved in thoſe climates, I think it rather under than above the true quantity. This evaporation muſt cauſe an increaſe of weight and denſity in the Atmoſphere, equal to the quantity of water that is raiſed, which weight will diffuſe itſelf by a motion toward where the weight and denſity is leſs; this will be either where the Atmoſphere becomes leſs denſe from being rarefied by the ſun's perpendicular rays, or where the greateſt quantity of vapour condenſes and falls in rain, both of which generally take place upon the land, becauſe of the greateſt heat being there, which from a conſtant influx of vapour below, and the elevation of the mountains and high land, it is forced into the higher regions, where being condenſed, it falls in rain; hence we find, that in all parts of the earth more rain falls upon the land and upon the ſea ſhores than does upon the ſea at a diſtance from land.

By eſtimating the evaporation between the Tropics at one-fourth of an inch, or (which is the ſame) at one-forty-eighth of a foot in 24 hours, the quantity riſing in that time from an Engliſh ſquare mile, will amount to 580800 ſolid feet of water, which is equal to 16205 tons; and from a ſquare degree of 69 Engliſh miles, it will be upwards of 77 millions of tons per day. Now as the conſtant trade-winds upon the Atlantic carry the vapour that riſes between the Tropics to the weſtward along with them, and (excepting what returns in rain upon the ſea) diſcharges it upon the continent of South

America, and the Weſt India Iſlands; therefore calculating the vapour that riſes between the latitude of 8 N. (that being the latitude of the mouth of the river Oronoque) and 23 S. to be carried upon the continent of South America, and allowing the ſpace for this vapour to riſe in to be from the Cape Verd Iſlands, in longitude 25 W. to the longitude of 52 W. upon the North ſide of the Equator, and from the longitude of 6 W. (being that of Cape Palmas upon the coaſt of Guinea) to longitude 38 W. upon the South ſide of the Equator, the whole of which comprehends a ſpace of 952 ſquare degrees, which multiplied by 77152000, the number of tons calculated to riſe in one degree, will amount to the enormous ſum of 73448704080 tons of water riſing in vapour from this ſpace in 24 hours. Now admitting all the vapour which the trade-winds bring in with them upon this ſpace, together with one-fourth of the above quantity to return in rain upon the ſea, the remainder being carried to the weſtward upon the land of South America, and falling there in rain, will furniſh ſufficient to ſupply a diſcharge of freſh water from this continent back into the ſea, equal to a body three miles and a quarter in breadth, and fifty fathoms deep, running at the rate of three miles an hour; and when we conſider the account given by travellers of the immenſe ſize of the great river Amazons, and add to it the great river Oronoque, and the number of other large rivers that diſcharge themſelves into the ſea along the vaſt extent of coaſt between the Bay of Carthagena in the Caribbean ſea, and the Rio Janeiro in the ſouthern part of the Brazils, together with the far greater part of the ſources of the great river Paraguay, or La Plata, it will not be found that the above eſtimation is much too great, or the above-mentioned evaporation any that ſignifies above the truth.

Upon calculating the diſcharge of a river, in order to compare it with this or any other eſtimation of the quantity of water flowing from it to the ſea, it is neceſſary to obſerve, that the velocity of the current upon the ſurface near the middle, is always too great to eſtimate the diſcharge of water by, becauſe of the obſtruction the water meets with in its courſe, from the roughneſs and unevenneſs of the ground in the bottoms and ſides, beſides which, rivers that lie upon a level are only impelled along by the weight of the water deſcending from the eminences upon their upper ends, and therefore it is only the ſurface that moves along, while the under parts (particularly if they are deep) lie almoſt ſtill with little or no motion. The obſtruction which the water in rivers meets with from the roughneſs and unevenneſs of their bottoms, is beſt ſeen when they come to be ſwelled with floods, from the ſuperior velocity of the water upon the ſurface, in a river when flooded and deep, to what it is when low, ſo that the diſcharge of water from a river may oftimes not amount to half what the current upon the ſurface would indicate, according to the dimenſions of a ſection of the diſcharging water.—Hence we ſee from the above calculation, and by attending to the true eſtimate of the quantity of water in the diſcharge of rivers into the ſea, that the vapour carried from the ſea upon the land is ſufficient, and forms the actual ſupply that maintains all the rivers and runs of water in the world; ſo that, (as hath been already mentioned) the quantity of vapour carried from the ſea and falling in rain upon the land, is exactly meaſured by the water that returns in rivers and runs to the ſea, unleſs it be ſuppoſed that any part is retained by the land; which cannot be the caſe, as ſince the flood the land muſt have been ſaturated with as much water as it will retain conſiſtent with the evaporations and other operations of the different climates and ſeaſons, and which appears to be further confirmed by the uniform flow of rivers ſuffering no alteration ſince the earlieſt ages recorded in hiſtory.

From the evenneſs of the ſurface of the ſea allowing the wind to glide ſmoothly along, there can be but little or no motion upward of the Atmoſphere upon it, except what is cauſed by the ſun's meridian heat where he is vertical, and the increaſe of this heat being far leſs than it is upon the land, the quantity of vapour forced up and condenſed in the higher regions muſt be but ſmall, which accounts for the leſs rain that falls upon the middle of the ocean than does upon the land and near it. But the winds reaching only to a ſmall height in the trades, the vapour that riſes above this height will be forced upward by the continual riſe of more below, on account of the riſe being greater than the condenſation; therefore an accumulation of vapour will take place, which will be greater, the farther to the weſtward; and thus by forcing more vapour into the higher regions as it increaſes, is the reaſon that where the trade-winds blow regular the farther to the weſtward, the more frequent the ſhowers are found to be. Theſe ſhowers generally fall in the afternoon and fore part of the night, on account of the higher vapour being then condenſed by the increaſe of cold by the ſun's withdrawing.

It is computed that water is about 811 times heavier than common Atmoſphere at the level of the ſea; therefore the quarter of an inch of water which is here eſtimated to riſe per day between the Tropics, will add to the Atmoſphere an increaſe of weight equal to a ſtratum of 203 inches, or nearly 17 feet in height; now by the former calculation a quarter of this is allowed to return in rain upon the ſea, and the reſt to be carried to the continent of South America, where falling in rain, the Atmoſphere there will be deprived of its weight, and the ſpace it occupied left vacant, which will facilitate the influx of more, and generate a motion of the vapour riſing upon the ſea toward where it condenſes and falls in rain upon the land, which muſt add to the velocity of the trade-winds; and by ſuppoſing theſe winds to be ſtrongeſt upon the ſurface of the ſea, and from thence decreaſing upward to one mile and a half in perpendicular height, where its motion ceaſes, the vapour thus moving to the weſtward with it will add about 10 or 11 miles in the 24 hours to its velocity.

Upon entering upon the continent of South America, the Atmoſphere carried to the weſtward in trade-winds will be forced into a higher region by mounting over the greater elevation of the land, and the rarefaction it undergoes from the greater heat there will force it higher ſtill, where the vapour contained in it will be condenſed into clouds by the higher cold, and from being higher than the trade-winds, ſome of theſe clouds are often ſeen moving back upon the ſea, and there diſcharge in rain. But the far greater part are forced in upon the land, by the continual preſſure of the trade-winds flowing in, where falling in rain, the water is immediately evaporated again by the heat of the climate, condenſes into clouds, and falls again in rain; and thus after ſucceſſive evaporations, condenſations, and precipitations, the greateſt part of this vapour is at laſt diſcharged in rain upon the higher lands and riſing grounds to the weſtward, particularly the eaſt ſide of the Andes and Cordilleras, there it is for the moſt part hindered from evaporating again, by its ſinking under the woods, foliage, and ſurface of the ground, where forming channels, it deſcends in runs of water down the declivities, which uniting, form ſtreams, and they rivers, which at laſt return to the ſea, and thus ſupply the deficiency occaſioned from the riſe of vapour.

The rain that falls upon the ſides of theſe mountains and high lands which does not evaporate again, will have its place ſupplied with more vapour arriving from the eaſtward, whoſe influx is facilitated not only by the natural courſe of filling of the vacancy in order to reſtore the equilibrium, but alſo by the attraction from the gravitation of the mountains, and the preſſure from the continual influx of vapour from the ſea. Thus it evidently appears, that how oft ſoever the rain formed from the vapour flowing in from the ſea upon this coaſt, may fall and evaporate again while traverſing the low level lands, yet the greater part by being either carried by the air, or by diffuſing itſelf through it, arrives at laſt upon the Eaſt ſide of the Andes and Cordilleras, where by falling in rain and collecting, furniſhes the principal part of the water in the Amazons, and other great rivers flowing from thence into the Atlantic, and very probably may add to the water of ſome of the rivers that flow into the Pacific Ocean; for it appears, that no wind or vapour comes over theſe mountains from the weſtward, becauſe of the plentiful ſupply from the Eaſt not ſuffering any, and becauſe the conſtant drain of Atmoſphere from their Weſt ſides, by the trade-winds upon the Pacific Ocean carrying with it the whole of the vapour raiſed there, alſo the great height of the Andes and Cordilleras ſuffers little or no vapour to paſs over them to the weſtward, ſo that the rains that fall upon the plains of Quito, as mentioned by Don Ulloa in his deſcription of that country, appear to be volumes of vapour floated by the ſun's meridian heat over the Eaſt ſide of the Andes, and condenſed by the increaſe of the evening cold, at which time the rain is always found to fall; alſo the ſnow lying upon the tops and down part of the ſides of the Cordilleras, muſt be part of this meridian vapour, which from the great height muſt be very thin and dilated, and ſo carried by a current of air up the ſides of theſe mountains, and there congealed into ſnow by the froſt, and from being very rare, it takes ages for the ſnow upon the tops of theſe mountains to accumulate; and it is very likely, that if their height was much greater, no vapour or ſnow would reach their ſummits. Don Ulloa alſo takes notice, that the Eaſt ſide of the weſternmoſt Cordilleras appeared arid and barren, while the Weſt ſide at the ſame elevation was green and covered with verdure, which plainly ſhows that but little vapour from the eaſtward reaches the weſtern part of the Andes; from which circumſtance there is every reaſon to ſuppoſe, that if there was an extenſive tract of low land lying between the Andes and Pacific Ocean, it would be burnt up for want of moiſture, becauſe no vapour would get over the Andes from the eaſtward to it, and the trade-winds, by carrying to the weſtward with them all the vapour raiſed from the Pacific Ocean, would prevent the receiving any from that ſide.

In equatorial climates, the rains that fall upon level plains that are clear of woods, where their ſurface are expoſed to the wind and ſun, are moſtly all evaporated again immediately by the heat: this ſudden evaporation, together with the heat that the vapour carries up with it, both ſaturates and warms the cold air which had ſunk from the higher region to fill the vacancy cauſed by the falling of the ſhower; and thus by ſpeedily rendering it of as warm a temperature as the neighbouring Atmoſphere, and by preventing the influx of vapour from thence, hinders in a great meaſure another ſhower; whereas woody and hilly countries, by withholding the influence of the wind and ſun from reaching the ſurface, and the declivities facilitating the water by deſcending to collect in runs under the foliage and ſurface, hinders evaporation taking place, and thus a ſecond fall of rain is promoted upon the principles already laid down, in the precipitation of clouds in rain.

Theſe obſervations concerning the falls of rain are corroborated from what we ſee in the Weſt India Iſlands; for thoſe iſlands that are leaſt cleared of woods by cultivation or otherwiſe, are by far the moſt rainy; and the ſame iſland, or even part of it, after being cleared, is much leſs rainy, and conſequently more healthy than before, for it is well known that the woody countries are the moſt rainy; alſo it is very common to ſee ſprings and ſmall runs of water dried up, which had flowed without interruption before the woods were cleared away, and the ground cultivated round them.— Clouds are always found to gather in greateſt quantity over mountains, becauſe of their attraction toward each other, which, together with the leſs evaporation upon them, cauſe more water to be collected upon mountains and riſing grounds than any where elſe, which burſting forth from their ſides and bottoms in ſprings, forms the ſource of rivers. Hence we ſee, that rivers derive moſtly all their water from mountains and high lands, receiving very little addition from the plains they glide through; indeed it is very probable, that in warm weather rivers traverſing extenſive plains, inſtead of gaining may loſe conſiderably by evaporation.

There is little or no vapour carried upon the continent of North America from off the Atlantic Ocean bordering its eaſtern coaſts, becauſe of the prevailing weſterly winds which blow from off theſe coaſts, ſo that the principal ſupply of vapour to water this continent muſt come by being carried from off the Weſt India Seas and Bay of Mexico, by the circulation of Atmoſphere moving from thence to the northward, where by frequent falls of rain and evaporation, together with diffuſion, it is diſtributed over the face of the country, watering the ground as it proceeds. There is no doubt but a part of the vapour for watering this continent may come from the North Pacific Ocean, by being carried with weſterly winds upon theſe weſtern coaſts, in the ſame manner the weſterly winds from the North Atlantic carry its vapour upon the continent of Europe; but then it is to be conſidered, that the weſtern coaſt of America is by far the higheſt land in it, being an immenſe chain of extraordinary high mountains, forming a barrier to hinder the weſterly winds from getting to the eaſtward over them; beſides which, the ſhape and poſition of the coaſt, by tending to the S. E. will induce the Weſt winds there to flow to the ſouthward, along this coaſt, in which direction it will be facilitated to proceed, for the purpoſe of ſupplying the ſource of the trade winds in the equatorial climates there, ſo that the ſupply of vapour from the North Pacific Ocean cannot be very great. The great extent and number of lakes in this country, by furniſhing an abundant evaporation, muſt contribute greatly toward keeping the country moiſt round them; but notwithſtanding which, and the many rivers and inlets of the ſea, the inland parts of the United States are in the ſummer frequently troubled with droughts; and when the country comes to be more clear of woods, the droughts very probably may be ſeverer felt.

In the climates without the Tropics, the moſt vapour will be condenſed, and the greateſt falls of rain take place, near to and upon the borders of the frozen regions, becauſe of the greater and more ſudden increaſe of the cold there, ſo that in the northern climates, by this cold increaſing and moving to the ſouthward in the fall of the year, and thus meeting and overtaking the vapour as it advances, will cauſe a greater condenſation and fall of rain in this ſeaſon, than in any other. In the ſpring, when the cold is receding, and the heat approaching, the air will, by being warmed, imbibe and retain more vapour, conſequently the condenſation and fall of rain will be leſs, but then the ſudden changes in temperature, eſpecially between the day and night, muſt cauſe condenſations and falls of rain; only, from the above reaſons, they are never ſo great or ſo laſting as they are in the autumn.

In the beginning of winter, as the froſty regions extend to the ſouthward upon the North American continent, from the froſt extending along the ſurface of the earth faſter than it does higher up, it arreſts and freezes all the vapour it meets on advancing, which falling, covers the ground with ſnow; thus from all the vapour being congealed, and falling in ſnow upon the outer ſkirts or margin of the froſty region, none of it reaches the central parts, ſo that the air in thoſe central parts being deprived of all its vapour by the froſt, the ſky remains clear and uninterrupted with clouds ſo long as the froſt laſts, which appears to be the caſe in the northern inland parts of North America, Hudſon's Bay, and the Daniſh ſettlements in Weſt Greenland, from the teſtimony of thoſe who have reſided in thoſe places, who aſſert, that after the winter froſt has ſet in intenſe, the ſky continues clear without any clouds, and the weather calm, or with light breezes, as long as the froſt laſts; which circumſtance agrees with what hath already been advanced, namely, that water in a frozen ſtate cannot be ſuſpended or float in the Atmoſphere, becauſe of the froſt depriving it of elaſticity, which appears to be the principal, if not the ſole cauſe of its floating in vapour: for ſhould it float without elaſticity, or ſome elaſtic ſubſtance attached to it to keep it expanded and ſeparate, let the particles be ever ſo ſmall, they muſt collect in maſſes by their gravity, and become viſible.

When the froſty region hath increaſed by the abſence of the ſun, ſo as to occupy a conſiderable ſpace, it will keep farther extending itſelf by the froſty Atmoſphere, from its ſuperior weight continually flowing out along the ſurface of the earth, and by freezing the vapour it meets on advancing, covers the ground it flows over with ſnow, and thus eſtabliſhing the cold there, it is enabled to incroach ſtill farther, by which means it is continually ſpreading farther and farther over the country, ſpreading rapider and extending farther, the greater the froſty maſs of Atmoſphere is that ſupports it, and will reſiſt the influence of the ſun in checking its progreſs, on account of the ſnow reflecting the greater part of his rays with their heat back through the Atmoſphere into empty ſpace, and in addition to this, the immenſe foreſts with which the continent of North America abounds, protect the froſt and ſnow from the ſun's influence; all which accounts for the winter cold reaching ſo far to the ſouthward, and of its continuing ſo long before the ſun's returning influence overcome it.

Although the winter froſt makes ſuch great progreſs upon the land, particularly upon North America, yet its progreſs is but ſmall in compariſon upon the neighbouring Atlantic Ocean, it never eſtabliſhing itſelf in full poſſeſſion farther than the ſea is frozen, which in moſt places, particularly upon the European ſide, ſeldom reaches to the ſouthward of the arctic circle: this in ſome meaſure muſt be owing to the fluidity of the water, by which the internal warmth or temperature of the earth is more readily communicated from conſiderable depths to the ſurface; and it muſt be from this cauſe that it is always obſerved that the deepeſt lakes are the longeſt in freezing; ſo that it is very probably owing to the greater depth of the ſea near Greenland, that leſs ice is formed upon it, and the floating ice reaches to a leſs diſtance from the Pole in moſt places there than in any other part of either Hemiſphere; alſo ſeveral circumſtances concerning the tides which may be obſerved upon the Weſt coaſts of Britain and Ireland, and the adjacent ſeas, evidently countenance the ſuppoſition of the North part of the Atlantic being very deep. The even and regular ſurface of the ſea is alſo inimical to the froſt, eſtabliſhing itſelf upon it by affording no ſhelter, and offering no impediment to guſts of ſoutherly wind with its warm vapour when puſhed by accumulation, or otherwiſe, from penetrating conſiderable diſtances to the northward.

The cold froſty Atmoſphere which in the winter ſeaſon frequently flows in ſtrong gales from off the North American coaſt, from its being deprived of vapour by the froſt, exhibits a curious appearance on its firſt coming in contact with the ſurface of the ſea, by its greedily receiving the vapour which riſes in great abundance, but from the air being too cold to retain it, the vapour is immediately condenſed, and falls down again, the whole reſembling ſteam riſing from a boiling caldron; the evaporation is briſkeſt, and the appearance greateſt when the wind blows ſtrong, and the froſt ſevere, but in falling, it never freezes till it touch ſomething; from which it appears, that it falls quicker than the cold can purſue it, and is not froze until attacked by cold from below, as obſerved before in the freezing of clouds. This appearance of ſteam is ſtill more conſiderable upon the froſty air arriving upon the gulf ſtream, on account of its greater warmth; but the air having by this time received a conſiderable degree of warmth from the extent of ſea it has paſſed over, together with what it receives from the ſtream, a great part of this appearance of ſteam evaporates and becomes inviſible again, and riſing to a greater height, condenſing, forms clouds, which often exhibit a very curious appearance, eſpecially when the aſcent of vapour is copious, ſeeming to the beholder as if they were continually mixing through each other in every direction, and ſome drops of rain falling from them, which appear to be cauſed by this internal motion, but ſeldom amounting to a ſhower. To the ſouthward and eaſtward of the gulf ſtream, the clouds are regularly formed, and the weather becomes ſqually with their ſhowers.

A ſhip from the coaſt of America ſailing to ſea before one of theſe froſty gales, will have the ſky upon and near the coaſt perfectly clear, but upon approaching the gulf ſtream it will begin to turn cloudy, by the warmth the Atmoſphere acquires on paſſing over the ſea enabling it to float vapour in a condenſed ſtate; and upon the ſtream, and towards its farther edge the ſky appears perfectly cloudy, from the greater degree of warmth it acquires there, floating an abundance of vapour, which condenſing into clouds, and they riſing rapidly to a greater height, produces the curious appearance above-mentioned; but at other ſeaſons, when the froſty gales do not prevail, there is no perceptible difference in the weather upon the gulf ſtream and that upon the adjoining ſeas.

During the ſummer ſeaſon and ſettled weather, the extraordinary quantity of vapour which riſes from the gulf ſtream to the eaſtward of New York, is by the prevailing ſoutherly winds carried to the northward upon the banks there, where being condenſed by the cold, produces the fogs ſo frequent upon all theſe banks at this ſeaſon; for it is a circumſtance well known, that fogs are more frequent, and continue longer upon the New England, Nova Scotia, and Newfoundland Banks, than upon any part of the European coaſts, which, in addition to the extraordinary quantity of vapour carried from off the gulf ſtream upon them, muſt be alſo owing to the greater cold of the ſea there communicated to the Atmoſphere, condenſing this vapour, for it is evident, that the water of thoſe ſeas comes in the ſpring and ſummer in a ſlow current from Greenland, Davis's and Hudſon's Straits, as appears by the immenſe mountains and fields of ice carried from theſe places to the ſouthward every year, whereas the water of the gulf ſtream and ſeas to the ſouthward circulates from the Weſt Indies.

There is an extraordinary circumſtance obſervable in theſe fogs, which perhaps may be found difficult to account for, namely, their being for the moſt part found upon ſoundings and near it, and that the ſhallower the water, the denſer and more prevalent are the fogs found to be. No doubt the greater warmth of the water in the deep ſea to the ſouthward of the Banks, by hindering the vapour from condenſing, is the cauſe of no fogs being there; but then it is found, that the intermediate ſpaces of deep water will be clear of fogs, while the ſurrounding banks are covered with them, even although theſe intermediate ſpaces of deep water comprehend but a ſmall number of miles, and when fogs are found upon this deep water, they appear not to be generated there, but carried thither by the wind. Now the fog not being upon theſe deep places between the banks, cannot be owing to the water there being warmer than that upon the banks, becauſe the water is continually moving from one to the other by the tides and other currents; from which it would appear, that there muſt be ſomething in the vicinity of the ground which encourages the formation of fogs. Perhaps the electric fluid may from the nearneſs of the ground riſe more plentifully in ſhallow water than in deep, and by inveſting the globules on being condenſed, enable them to float there in greater plenty. Theſe fogs are moſt prevalent in the ſpring and beginning of ſummer, becauſe then the ſoutherly winds prevail moſt, for the purpoſe of ſupplying the eaſterly circulation that is carrying on to the northward at this ſeaſon.

Although in general more rain falls upon coaſts and near them than does upon the middle of the ocean, yet rain is frequently produced upon the North Atlantic, from the accumulation and joſtling of clouds by the meeting of winds, whether angularly or in oppoſite directions. Theſe meetings of winds are generally from the South and North, but the eaſtern circulation inclines each of theſe from the weſtward, ſo that in general they may be reckoned from S. W. and N. W. The former is generally loaded with vapour, which being condenſed and precipitated in rain, by the cold and agitation cauſed by the latter, a ſquall is commonly produced where they meet. If the northerly wind prevail over the ſoutherly, the rain and ſquall will be heavier, becauſe of more vapour being condenſed by it; but if the ſoutherly wind prevail, the rain and ſquall will be leſs violent, becauſe great part of the vapour will be imbibed by the dry northern Atmoſphere, from its being warmed by that from the ſouthward; and though upon the ſoutherly wind prevailing, the firſt rain on uniting be leſs, yet partial rain will afterwards continue to deſcend, by the continual condenſation of vapour from the additional cold it meets with on advancing North.—Hence the reaſon of the common obſervation among ſailors, that the wind changing to the right hand (that is from Weſt toward the North) brings fine weather, but changing toward the left always brings foul weather.

The Britiſh Iſles lying in the tract of the weſterly winds from the Atlantic Ocean to the Continent of Europe, and by being the firſt land this wind meets with, the vapour by being forced into a higher region from the elevation of the land of the weſtern coaſts, receives there its firſt and greateſt condenſation; conſequently more rain falls upon this Weſt coaſt than upon the Eaſt, or upon any of the inland countries of Europe. The fall of rain in theſe parts is greater in the fall and beginning of winter, than at any other ſeaſon of the year, for in addition to the increaſing cold of this ſeaſon, the eaſtern circulation of the Atmoſphere over the Atlantic, which before was partly carried on in the northern Greenland Seas, is now altogether confined to the ſouthward between the Banks of Newfoundland and the Weſtern Iſlands, in which it takes the Britiſh Iſles in its tract, and thereby brings a greater quantity of vapour upon them; conſequently we find, that the more prevalent the

Weſt and S. W. winds are from off the Atlantic Ocean, the rainier the ſeaſon will be; and that the ſinking down of the higher cold air helps to continue the rain, and renders a rainy ſeaſon always a cold one, and often produces night froſts in the interval between the ceaſing of the ſhower and the influx of more vapour; alſo the clear weather common in theſe intervals, is the conſequence of all the vapour having been condenſed and precipitated by the froſtineſs of the deſcended Atmoſphere, and it is on account of the deſcent of this higher Atmoſphere, that clouds are never ſeen floating at a very high elevation after an extenſive fall of rain.

In the winter ſeaſon, the froſty maſs of Atmoſphere diffuſing itſelf along the ſurface of the earth by its ſuperior weight, and concondenſing the vapour it meets with, covers the ground with ſnow as it advances over the continent of Europe, in the ſame manner as already deſcribed of the winter in North America. This froſty Atmoſphere in flowing off frequently reaches Great Britain in winds from N. E. Eaſt and S. E. directions, bringing with them the intercepted vapour congealed into hail or ſnow, which is more abundant on account of the great ſupply from the ocean, which coming through a higher region, and in other directions, is again returned by theſe froſty winds below. The more ſoutherly the wind is from the ocean that brings it, the more vapour will it contain, becauſe of its greater warmth; ſo that we find S. E. and Eaſt winds to bring the greateſt quantity of ſnow, becauſe they return with the vapour brought in by the S. W. winds, which at that time will be found to prevail on the Weſt coaſt of France, and entry of the Britiſh Channel, whereas the North and N. E. winds which return the vapour brought by the Weſt winds round the North of Britain, tho' coldeſt, bring the leaſt ſnow;—but the greateſt falls of ſnow often take place where a S. W. wind loaded with vapour meets a N. E. one. If the N. E. wind prevail, the ſnow lies upon the ground, but if the S. W. prevails, it melts and diſappears.

As the weſterly winds are the moſt prevalent, flowing in from the ocean upon the Weſt coaſts of Europe, it may be eaſily ſeen that the vapour for watering the face of the country and ſupplying the rivers there, is moſtly brought in by theſe winds, for the winds that prevail upon the northern ſhores of the Mediterranean being from the northward, little vapour from that ſea will be carried that way; and it may be very probable, that during the ſummer months ſome part of the vapour from the Atlantic Ocean after ſucceſſive evaporations and by diffuſions may reach as far as the weſtern part of the continent of Aſia.

Upon the Weſt coaſt of Africa, between Cape Verd and Cape Palmas, the quantity of vapour which riſes muſt be very great, from the great heat there; but on account of the drain of Atmoſphere continually carried to the weſtward by the trade-winds, it is left to condenſe and fall in rain upon the coaſt and adjacent ſea, becauſe there is no current of Atmoſphere to carry it to any conſiderable diſtance inland. In the day time, during the ſea breeze inclining the wind upon the land, the vapour may be ſeen toward afternoon condenſing and forming in large heavy clouds upon the coaſt, which toward night moves off by the land breeze, and diſcharge themſelves upon the ſhore and near it in heavy torrents of rain, which, from its quantity, and the height from which it deſcends, produces heavy ſqualls or tornadoes, which are ſometimes ſo furious as to reſemble ſmall hurricanes. Theſe rains here, as well as in all hot countries, are moſt prevalent at the ſeaſon the ſun is vertical, and always begin to fall upon the ſun's retiring in the afternoon, and from thence continue all night, or until the vapour is exhauſted.—Alſo it is to be obſerved, from the ſcanty ſupply of Atmoſphere for ſupplying the trade-winds here, that the ſpace to the weſtward lying as it were under the eddy of this coaſt, have the winds more variable than they are either to the northward or ſouthward of it, and by having the N. E. trade-winds on the North ſide, and the S. E. on the South, this ſpace turns narrower the farther to the weſtward, until it terminates in their meeting; and from the vapour carried and thrown into it by theſe winds, together with what is continually riſing not having winds to carry it all away, an accumulation of vapour muſt take place, which from the internal motion incident to it, as an eddy, is continually falling in rain, and hence this ſpace of ſeas is by ſailors called *the Rains*.

The vapour carried in by the conſtant ſea breeze that blows in upon the ſouthern coaſt of Africa, to the eaſtward of Cape Palmas, produces falls of rain upon that coaſt ſimilar to thoſe upon the coaſt North of it already deſcribed; only the rain here reaches to but a very little diſtance upon the ſea, becauſe of the wind blowing from thence; and it alſo reaches to but a ſmall diſtance inland, becauſe of the ſea breeze bending its courſe to the eaſtward, for ſupplying the drain of Atmoſphere out of the Gulf of Guinea; indeed all that part of the Weſt coaſt of Africa lying between the Tropics can have but very little vapour penetrate from the ſea to the inland parts, unleſs it be by diffuſion, becauſe of the trade-winds continually draining the Atmoſphere away to the weſtward; ſo that the vapour for watering the interior of this country muſt come either from the Indian Seas, or from the Mediterranean. That which comes from the Indian Seas muſt have the far greater part of it condenſed and fall in rain upon the mountains and high lands on the eaſtern part of this continent, where by collecting in runs and rivulets, forms the ſources of the great rivers that flow from thence. But that from the Mediterranean (by being the far greater part of the vapour which riſes upon it) might at firſt ſight lead us to imagine that this continent would be plentifully watered thereby, and there is no doubt but great quantities of rain fall upon the mountains and high land in the northern parts of it; but then it muſt be conſidered that the warmer the Atmoſphere is, the more vapour it will ſuſtain afloat in it, therefore the vapour that riſes in the temperature of the Mediterranean will continue to float upon the low lands of the continent of Africa, particularly in the interior, becauſe of the greater heat there. Now the vapour from both the Mediterranean and Indian Seas, being in great part condenſed and precipitated on paſſing the ranges of mountains contiguous to their coaſts, (which indeed appear to be the higheſt land in Africa,) what remains to be carried by ſucceſſive evaporations to the ſouthward and weſtward over theſe mountains into the interior, will not be ſufficient, from the greater heat of the climate, to ſaturate the air there, conſequently it is kept ſuſpended in it; and the air, from not being ſaturated, will ſuck up all the moiſture it gets hold of, leaving the ground parched and barren; hence the cauſe of the extenſive deſerts which we are told cover great part of the face of the interior of this continent.

An inſtance ſimilar to this, (where great part of the vapour, by being condenſed and precipitated upon paſſing over high lands, and leaving none to fall upon the plains beyond it,) is viſible in that ridge of high land called the Ghauts, in the Eaſt Indies, where according to the ſeaſon of the year, the ſide the wind blows upon is continually rainy, by the condenſing of the vapour, upon its being forced into a higher region by the riſing of the land, whereas no rain falls upon the oppoſite ſide, becauſe the vapour that eſcapes over the tops of the high land, by not being ſufficient to ſaturate the air, is ſuſpended in it, ſo that the weather there is fair and pleaſant.

The low lands of Peru in South America, is another inſtance of this kind, becauſe no vapour getting over the Cordilleras to them from the eaſtward, and the trade-winds not ſuffering any to come from the ſea to the weſtward, is the cauſe that in many parts it never rains there. Indeed it may be commonly obſerved where there is an extenſive range of mountains, that the weather will be generally fair under their lee, while it rains on their weather ſide.

The ſouthern part of the continent of Africa lying between the South Tropic and the Cape of Good Hope, will be watered by vapour from the ſurrounding ſeas, carried in upon it by the different winds that prevail there—the weſtern ſide and inland parts, by the prevailing Weſt winds from off the South Atlantic flowing in upon it, and the eaſtern coaſt by the ſea breezes from off the Moſambique Channel.

Having now finiſhed the deſcription of the circulation of the Atmoſphere through its various courſes over the Atlantic Ocean, together with that of the vapour as it is condenſed and precipitated throughout this circulation, I ſhall conclude, and ſum up the whole by obſerving, that it evidently appears, from what hath been advanced, that the original circulation of the Atmoſphere mentioned in the beginning of this work, as carried on from the Polar cold to the Equatorial heat in the lower regions, and the contrary in the higher, is upon the Atlantic Ocean combined with another circulation carried on horizontally in the lower regions by the trade-winds, which is continually flowing to the weſtward in the equatorial climates, and returning again to the eaſtward through the climates between thoſe and the Polar cold. And that the South and North circulations carried on in the lower and higher regions is briſkeſt upon and near the borders of the northern froſt, becauſe it is there that the greateſt difference between heat and cold comes within the leaſt diſtance of each other; therefore in the ſummer months, by theſe borders being removed ſo near the Pole, this South and North circulation muſt be carried on briſkeſt there, and thus leave a larger ſpace for the other circulation cauſed by the trade-winds to perform its revolution, by which means the Atmoſphere will have a greater diſtance to move to the northward in ſoutherly winds, through the higher and lower regions along the North American coaſts, and alſo to move to the ſouthward in northerly winds, in the lower region over the continent of Europe and its coaſts, before it arrive at the ſource of the trade-winds. But in the winter ſeaſon, when the circulation is removed farther from the Pole, from the froſt not reaching near ſo far to the ſouthward upon the weſtern European coaſts, as it does upon the eaſtern American coaſts, the northern courſe of the Atmoſphere upon the latter coaſt is but very ſhort, and therefore muſt proceed in a N. E. direction acroſs the Atlantic Ocean, in order to its getting far enough North for ſupplying the ſouthern flow of Atmoſphere from the margin of the froſty region upon the northern parts of the European coaſts.

The circulation of the Atmoſphere, in its courſe to the eaſtward and ſouthward, is found upon the European ſide to proceed at times in a different direction to what it does at others; ſometimes it proceeds to the ſouthward, round, or perhaps to the weſtward of the Britiſh Iſles, along the coaſt of Spain and Portugal toward the trade-winds, and at other times by taking a wider circuit it proceeds up the Baltic, the valleys of the rivers in Germany, and over the lowlands there, and from thence to the ſouthward over the Mediterranean. Now as that circulation which comes from the warmeſt climates, and immediately from off the ſea, will carry a much greater quantity of vapour with it than that from a cold climate, and from off the land, it hence follows, that the different courſes which the circulation takes upon the weſtern parts of Europe is evidently the cauſe of the ſeaſons being ſo variable there; for inſtance, with reſpect to Brirain, when the chief bent of the eaſtern circulation takes its courſe from the Weſtern Iſlands, N. E. over the Britiſh Iſles, up the Baltic, and over Germany, the great quantity of vapour which this wind muſt be loaded with will render the ſeaſon a rainy one, and the ſtronger this wind is, the more vapour and the more rain will attend it; but if the circulation to the eaſtward by being feeble is turned, and proceed to the ſouthward before it reach the Britiſh Iſles, the ſeaſon then will be warm and pleaſant.—

Again, when the circulation comes over the Greenland Seas, and from thence proceeds South along the coaſts of Norway, and over the Britiſh Iſles to the ſouthward, the ſeaſon will be cold and blighting; but if this Greenland circulation proceeds over the continent of Europe without coming near the Britiſh Iſles, and no circulation from the Weſt or S. W. come to Britain, the ſeaſon then will be dry and parching; from which it is evident, that a knowledge of what courſe the circulation may take will lead to a knowledge how the ſeaſon as to weather will turn out, a circumſtance which would be of the moſt beneficial ſervice to mankind, and to attain which obſervations might be conſtantly made in each country concerning it, which by diligently comparing, might in time make conſiderable advances towards the diſcovery of this moſt uſeful and important object.

OBSERVATIONS
ON THE
INFLUENCE OF THE MOON
UPON THE
ATMOSPHERE.

THERE is no doubt but that the influence of the Moon raiſes tides in the Atmoſphere in the ſame manner it does in the ocean, and as ſuch muſt have ſome effect in diſturbing it. The tides in the Atmoſphere muſt riſe higher than thoſe in the ocean of the ſame perpendicular depth, in proportion as the Atmoſphere is farther removed from the centre of the earth; but from the elaſtic property of the Atmoſphere, its parts will riſe by being extended upwards toward the moon's influence, by which means there is no void left for the lateral parts to ſink in and fill up, as in the ocean. It is true, the riſe of the tide in the Atmoſphere, by cauſing an expanſion, will cauſe a diminution of its ſpecific gravity, particularly in the upper part, which will induce the neighbouring Atmoſphere to flow in, in order to reſtore the equilibrium. But from the ſmall proportion which the depth of the Atmoſphere bears to the ſemi-diameter of both the earth and Atmoſphere, and from the convex form of the earth's ſurface, the tide raiſed by the moon will only occupy the ſpace immediately underneath her direct influence, as it is bounded by the interception this influence meets with from the earth's ſurface, ſo that the remaining part of the ſemi-circumference of the Atmoſphere (which muſt be by far the greateſt portion of it) will act as lateral parts; therefore the ſupply to reſtore the equilibrium of denſity cauſed by the riſe of the Atmoſpheric tide, will be ſo inſignificant with reſpect to the extent and magnitude of the lateral parts, as ſcarcely to be perceptible in reducing the level; beſides, the diminution of denſity by the lunar influence being but ſmall, the flowing in of the lateral parts to reſtore the equilibrium will be but ſlow, conſequently the moon's influence will be paſt before any great progreſs in flowing in takes place, therefore there will be but very little depreſſion below the common level of the Atmoſphere at right angles with the line of the moon's attraction, ſo that from ſo little depreſſion taking place in the tides in the Atmoſphere, theſe tides will conſiſt of but little more than a riſe above the common level, anſwering to half a tide in the ocean, and are only ſo much greater than the latter in an ocean of equal depth, as the former is in proportion farther removed from the earth's centre.

Since the principal effect of the tides in the Atmoſphere conſiſts in leſſening its gravity toward the earth, thereby rendering it of leſs denſity underneath where the moon is vertical, and as the Atmoſphere encircles the earth every way, the moon's influence and the tide raiſed by it will move uniformly over the ſurface of the earth, according to its diurnal motion in a lunar day, ſo that theſe tides will be perfectly regular, and their effect a ſimple riſe and fall in the Atmoſphere, the greateſt elevation being always a little Eaſt of where the moon is vertical and oppoſite. Theſe tides will be of leſs elevation upon the land (particularly if high) than upon the ſea, becauſe of the leſs depth of Atmoſphere upon the former for the moon's influence to act upon.

From the alteration in the denſity of the Atmoſphere cauſed by the tides, it is evident, that they muſt have ſome effect upon the weather; theſe effects upon the weather will be moſt conſpicuous in the equatorial climates, becauſe of the greater influence of the moon there, and becauſe the Atmoſphere (more eſpecially the denſeſt part of it) is there of the greateſt perpendicular dimenſions; alſo any change of influence upon it will be eaſier perceived between the Tropics than in any other place, on account of the greater regularity of the weather there. Accordingly the inhabitants of the Weſt Indies make a remark, that the weather is always more turbulent and ſqually about the full and change of the moon, than it is about the quarters; and it is alſo remarked, that hurricanes for the moſt part (if not always) commence near the full or change of the moon, all of which evidently diſcover the influence of the moon to have an effect upon the weather in theſe climates; and no doubt tho' the effect be leſs, yet it muſt have ſome upon the weather in climates diſtant from the Equator.

By the influence of the moon leſſening the denſity of the Atmoſphere, it will not then be able to ſupport the ſame quantity of vapour which before floated in it; therefore when the Atmoſphere is fully loaded with vapour, this diminution of denſity will oblige it to let part of it go, which by condenſing will fall in rain, and thereby produce ſqualls. This diminution of denſity by the Atmoſpheric tides will be greateſt at the full and change of the moon, becauſe of the ſun's influence being then in conjunction with the moon's, which accounts for the weather in the Weſt Indies being more turbulent at that time, as above-mentioned; and may no doubt be the cauſe of the commencement of a hurricane, by the Atmoſphere then letting go a load of vapour, which otherwiſe it might ſuſpend, until by partial condenſations about the remote parts, this load might be gradually led to diſperſe.

OBSERVA-

OBSERVATIONS

UPON THE

RISE AND FALL OF THE MERCURY

IN THE

BAROMETRICAL TUBE.

IT will readily appear, from accumulations and exhauſtions, occaſioned by the circulations of the Atmoſphere, as deſcribed in the foregoing ſheets, together with condenſations and rarefactions cauſed by cold and heat in it, that the weight of the column will be different both as to elevation and denſity, and conſequently as to weight, in different places as well as at different times, in the ſame place. Therefore ſince the column of Mercury in the Barometrical Tube meaſures the weight of the column of Atmoſphere, I ſhall here, by forming an eſtimate of the proportional weights of the column of Atmoſphere, through the different parts of theſe circulations, endeavour to deſcribe or point out the general elevations of the Mercury in the Barometer, according as theſe weights are more or leſs with reſpect to each other, from the cauſes that produce them.

The principal circulations of the Atmoſphere over the North Atlantic Ocean, and the continents bordering it, as deſcribed in the foregoing ſheets, may be reduced to theſe two, namely, a North and South circulation, cauſed by the general heat and cold exiſting in the equatorial and Polar climates, carried on South in the lower, and North in the higher regions. And a horizontal circulation carried on in the lower region by the trade-winds flowing to the weſtward in the equatorial climates, and returning to the eaſtward in variable winds between theſe climates and the Poles. Now theſe two circulations, though different in themſelves, are through their whole extent found for the moſt part combined together, which renders it difficult to ſeparate the effects of the one from that of the other; therefore in order to inveſtigate the ſubject properly, it will be neceſſary to conſider the effect of each circulation ſeparately, and afterward the effect which the deſcent of water out of the Atmoſphere will have, by leſſening the weight of the column; ſo that by finding the due effect of each of theſe when acting ſeparate, and their proportion when in combination, an eſtimate may be made of the weight of the column of Atmoſphere, and conſequently of the riſe and fall of the Barometer, and a knowledge obtained of its true cauſe.

In the South and North circulations, the column of Atmoſphere will be heavier at the centre of where is the greateſt extent of heat, becauſe of the conſtant influx of colder and denſer Atmoſphere raiſing the column to a greater height; and its weight will alſo be increaſed by the great quantity of vapour raiſed and ſuſpended there by the heat. And again, the column of Atmoſphere will be likewiſe heavier where the greateſt extent of cold is, becauſe the condenſation it receives by the cold ſhortens the column, by which means the neighbouring higher Atmoſphere will flow in upon it, in order to reſtore the level, and thus by adding to its height (otherwiſe ſhortened by condenſation) will increaſe the weight. It is to be obſerved, that the larger either of theſe ſpaces of greater heat and of greater cold is, the leſs fluctuating will the weight of the column in the centre be, becauſe the flowing in and out of the Atmoſphere to and from them, only taking place upon their outer edges, it follows, that the farther theſe edges are removed from the centre, the column there will be leſs affected by the motions cauſed by theſe flowings out and in.

Now ſince the column of Atmoſphere is heavieſt in each of the ſpaces where the greateſt heat and where the greateſt cold is, it of courſe will be of leſs weight in the intermediate ſpace between them; for although this ſpace, from the fluidity of the Atmoſphere, will have the height of the column a medium between the heights of the other two; yet from the temperature being generally found to approach much nearer that of the warmer, its denſity, and conſequently its weight will be in proportion leſs than the medium. For inſtance, by eſtimating the centre of the greateſt heat to be upon the Equator, and that of the greateſt cold to be at the North Pole, the temperature of the former to be at + 85 of Farenheit's Thermometer, and that of the latter to be — 40 of the ſame, the medium between theſe is + 22½, which is conſiderably below freezing, whereas experience ſhews, that in the latitude of 45 (the intermediate ſpace as to diſtance when the ſun is in the Equator) that the temperature in moſt parts of the northern Hemiſphere is above freezing, and in many parts conſiderably ſo, conſequently the denſity of the column muſt be leſs than the medium between the denſities upon the Equator and at the Pole, and from its height (which from the fluidity of the Atmoſphere) being only a medium between the other two heights, its weight muſt be evidently leſs. Therefore becauſe of the decreaſe in height of the column as it nears the Polar cold, the farther North the warm temperature extends, the leſs will be the weight of the column, ſo long as the cold over the North Pole remains in its full vigour; and ſince the warm temperature approaches nearer the Polar cold upon the Weſt coaſts of Europe, than any where elſe in this Hemiſphere (and that more particularly in the winter ſeaſon, becauſe then the Polar cold is moſt intenſe) the column of Atmoſphere as affected by this circulation, will be of leſs weight there than in any other part of it; and from the circulation being carried on briſkeſt in this intermediate ſpace, it will be more ſubject to accumulations and exhauſtions, and conſequently the weight of the column will be more fluctuating. Theſe fluctuations will be increaſed in thoſe parts where the froſt and a warm temperature takes poſſeſſion alternately, becauſe the condenſation by the froſt by ſhortening the column, will cauſe the Atmoſphere in the higher region to flow from off where the warm temperature is upon the frozen column, in order to preſerve the level, thereby increaſing the weight of the froſty column, while at the ſame time it diminiſhes that of the other.

The horizontal circulation of the Atmoſphere cauſed by the trade-winds, will have the elevation and weight of the column as affected by it, greateſt upon the place where the ſun's influence in producing the trade-winds terminates, becauſe the farther progreſs of the circulation from thence is only cauſed by the trade-winds puſhing it on, which produces an accumulation, from the reſiſtance it there meets with; and it is from this accumulation diſperſing onward that its farther progreſs is promoted, upon the principle that a ſtream of water iſſuing into one end of a canal, muſt raiſe the level there before a current commences toward the other end.—This termination of the ſun's influence in promoting the trade-winds, takes place between the Tropics, upon the Eaſt coaſt of America, the Carribbean Sea, and Bay of Mexico, where an accumulation is likewiſe cauſed, by the circulation changing its direction from Weſt to North, which adds ſtill more to the elevation of the column.

Again, the leaſt elevation of the column of Atmoſphere from the horizontal circulation, muſt take place upon thoſe parts from whence the Atmoſphere is drawn to ſupply the trade-winds, as they are forced to the weſtward by the ſun's influence, upon the principle that a ſtream of water iſſuing out of one end of a canal, muſt lower the level there before a current toward it commences from the other end; and as thoſe parts from whence the Atmoſphere is drawn to ſupply the trade-winds muſt be the weſtern coaſts of Africa lying between the Tropics, therefore the column of Atmoſphere as affected by this circulation, ought to be of leaſt elevation there; and the intermediate parts between theſe two extremes of this circulation, will have the elevation of the column as affected by it, a medium between them, according as they are ſituated, the column being higher as they are nearer the Eaſt coaſts of South America lying between the Tropics, and lower as they are nearer thoſe parts of the weſtern coaſts of Africa which lie between the Tropics.

Theſe circulations being carried on in different directions over the ſame ſpace, and the alteration in the weight in the column of Atmoſphere occaſioned by each being different, both as to cauſe and ſituation; it hence follows, that in moſt places the weight of the column according to one circulation will be different from that according to the other, ſo that in this caſe the true weight of the column will be a medium of both, according as the effect of each prevail; and it is from this medium the comparative height of the Barometer in each particular place is to be aſcertained.

It hath been ſhown, that by the South and North circulation the greateſt elevation of the column of Atmoſphere is in the equatorial climates, on account of the greater heat there, and that by the horizontal circulation both the greateſt and leaſt elevation of the column, as cauſed by it, is alſo there; the firſt being upon thoſe parts of the Eaſt coaſts of America that lie between the Tropics, the Carribbean ſea, and Gulf of Mexico, and the leaſt elevation upon thoſe parts of the weſtern coaſts of Africa which lie between the Tropics. Now from the greateſt elevation of the column of Atmoſphere by both circulations, taking place upon thoſe parts of the eaſtern coaſts of America that lie between the Tropics, the Carribbean ſea, and more particularly the Bay of Mexico, the Barometer in theſe places muſt be of a great height, and indeed ought to be higher there than upon any other part of theſe circulations. But upon thoſe parts of the Weſt coaſts of Africa, which lie between the Tropics, although the column of Atmoſphere is higheſt there, by the South and North circulation, yet it is loweſt by the horizontal; therefore the true elevation of the column muſt be a medium between them, and the height of the Barometer accordingly.

Again, it hath been ſhown, that by the South and North circulation the weight of the column of Atmoſphere is leaſt in the intermediate ſpace between the greateſt heat and greateſt cold, more particularly upon the Weſt coaſts of Europe, becauſe there the warm temperature approaches neareſt the Polar cold. But there the elevation and denſity of the column, by the horizontal circulation, ought not to be much below a medium between its greateſt and leaſt elevation; therefore the height of the Barometer there will be accordingly, which will be lower than any other part of the circulation, though not ſo low as the joint effects of both circulations would produce by the parts where each are loweſt coinciding.

The effects of the South and North circulation upon the elevation and denſity of the column of Atmoſphere, will be ſhifted and materially altered by the ſun's declination; for when he has North declination, the great ſeverity of the froſt round the North Pole being then in great part done away, the greater weight of the column of Atmoſphere cauſed by its condenſation, is likewiſe done away, and conſequently the elevation and weight of the column in the middle between the ſpaces of greateſt warmth and greateſt cold, will be more than it is in the winter ſeaſon; and it alſo will, together with the ſpace of greater heat, be removed nearer to the Pole, by which means the general elevation of the column of Atmoſphere in the northern Hemiſphere, will be greater in ſummer than in winter, and the Barometer higher in the ſouthern parts of it.

It is to be obſerved, from the foregoing circumſtances, that where the circulations and temperature are moſt regular, the weight of the column of Atmoſphere will be leaſt fluctuating; therefore, as the greateſt regularity in theſe takes place in the trade-winds, ſo we find the weight of the column of Atmoſphere ſhown by the Barometer, to be moſt regular there alſo; and ſince the circulations and temperature are moſt irregular upon the northern parts of the Weſt coaſts of Europe, (more eſpecially in the winter ſeaſon) ſo we find the heights of the Barometer to be moſt fluctuating there; and the fluctuations of the Barometer are greater upon the land than they are upon the ſea, on account of the greater variety in temperature, and the obſtruction the Atmoſphere upon the former meets with in its free circulation, from the unevenneſs of the ſurface.

Within the trade-winds, and where the ſea breezes are conſtant and uniform, it is found that the Barometer is very regular, riſing during the day until toward four o'clock in the afternoon, or to near ſun ſet, and from thence falling during the night until morning. The riſe of the Barometer during the day is cauſed by the flowing in of the lower Atmoſphere toward the ſun's meridian heat, by which the column is elevated to an extraordinary height, and its falling during the night is occaſioned from the Atmoſphere ceaſing to flow in below, and from the column from its greater elevation diſperſing in the upper region, until it is of the ordinary height. This riſe and fall in the Barometer in the equatorial climates, will be greater upon the land than it is upon the ſea, becauſe of the greater difference there is in the temperature between day and night cauſing the ſea breeze in the former, which elevates the column, and the land breeze flowing off to the ſea during the latter, which depreſſes it.

This regularity in the heights of the Barometer in the equatorial climates, ceaſes on advancing from thence North upon the continent of America, and its adjoining ſea, becauſe of the circulation becoming variable there, and from the ſea breeze ceaſing to be conſtant, the riſe and fall during the day and night ceaſes alſo; and from the inland parts of this continent being rather out of the way of the direct courſe of the circulation, together with the obſtructions the Atmoſphere, in its free circulation, meets with, from the ruggedneſs of the ſurface, the Barometer will be more fluctuating there than upon the coaſts, particularly near the borders of the froſt.

Upon the Atlantic Ocean bordering this coaſt, the fluctuation of the Barometer will be leſs than it is upon the land, owing to the facility of circulation the Atmoſphere has along its ſmooth and level ſurface. But from being ſo little removed from the Carribbean ſea and Bay of Mexico, and from the horizontal circulation here changing its courſe from North to Eaſt, the eaſtern parts of this continent and the ſea adjoining to it will have the Barometer in general very high; and from the leſs elevation of the column, its leaſt height will be always found where the temperature borders upon the froſt.

The Weſt coaſts of Europe, particularly the northern part, (as hath been already mentioned) have the Barometer lower than any other part of the circulations; this more particularly happens when the horizontal circulation is carried on ſtraight to the eaſtward over the continent, before it changes its direction to the ſouthward; but when the circulation turns to the ſouthward upon the coaſt, or before it quite reaches it, the obſtruction which muſt attend the change of direction will produce an accumulation, and raiſe the Barometer; therefore as the change of the circulation upon the Weſt coaſts is generally attended with fine weather, we for the moſt part prognoſticate good weather from a high Barometer, whereas the circulation when carried direct on to the eaſtward over the continent of Europe, is commonly attended with rain on the weſtern coaſts, on account of the quantity of vapour carried from off the ſea by it; and theſe falls of rain interrupting the regularity of the current of Atmoſphere, with the other effects the fall of rain hath upon the weight of the column, renders the Barometer fluctuating. Hence a low and fluctuating Barometer generally attends weſterly winds and rainy weather upon the Weſt coaſts of Europe. Eaſterly winds from off the Weſt coaſts of Europe, from their being in oppoſition to the general circulation, produce an accumulation and raiſe the Barometer, but N. E. winds in the ſpring and beginning of ſummer, when forming part of the circulation over the Green-

land

land ſeas, in its progreſs from thence to the ſouthward, ſeldom raiſes the Barometer.

The obſtruction the circulation of the Atmoſphere meets with from the irregularity of the ſurface of the land upon the inland parts of Europe, renders the Barometer there more fluctuating than it is upon the coaſts, which, added to the greater fluctuation it otherwiſe has upon this part of the circulation, renders it ſtill more ſo, particularly upon the N. E. parts, comprehending Sweden, Ruſſia, and Poland, from their lying as it were upon the outer ſkirts of the tract of circulation; for by being removed to ſuch a diſtance from both the Atlantic and Mediterranean ſeas, a vein or current of Atmoſphere being drawn from theſe parts toward the latter ſea, may cauſe a conſiderable exhauſtion of Atmoſphere before a ſupply from the Atlantic finds its way to fill it up; and again, when the current of ſupply commences, the current toward the Mediterranean may, from the effect of the exhauſtion or other cauſe, be ſtopped, by which means the ſupply ruſhing in, will produce an accumulation before the current to the ſouthward is again put in motion; hence the Barometer will be found to riſe and fall more in theſe countries than in any other part of the circulation; alſo, the fluctuations in theſe countries will be increaſed by the near vicinity of heat and cold that frequently take place in the ſpring and autumn, from the Atmoſphere in the higher region flowing from off the warm ſpace upon the cold, in order to fill up the deficiency in elevation cauſed from the condenſation by the latter, and thus reſtore the level.

The increaſe of heat in the South of Europe, and upon the Mediterranean, will make the Barometer higher there than upon the North of Europe, upon the principles laid down in the South and North circulation, and will become leſs fluctuating from the greater uniformity in the temperature of the Atmoſphere, the nearer it is to the Tropic, until in the trade-winds, where it is uniform, riſing during the day, and falling in the night.

But beſides the alterations in the Barometer, produced by the circulations and difference in temperature, there is another cauſe of alteration, namely, the deſcent of a quantity of water out of the Atmoſphere, whether in rain, hail, or ſnow; for it is evident, that where a quantity of water falls out of the Atmoſphere upon the earth, the weight of the column will be diminiſhed a quantity equal to the weight of the water that falls; conſequently the Mercury in the Barometer muſt there fall in proportion; hence we generally ſee, that the Barometer always falls wherever a heavy ſhower deſcends, and that it generally riſes again ſhortly after, owing no doubt to the ſurrounding Atmoſphere flowing in to reſtore the equilibrium; but the fall of the Barometer in conſequence of a ſhower is never ſo great where it falls as it is round its outer limits, becauſe the preſſure of the Atmoſphere carried down by the ſhower always acts upon it in keeping up the elevation; whereas, without the ſhower, the decreaſe of weight hath its full effect in leſſening the weight of the column.

In the foregoing obſervations reſpecting the riſe and fall of the Mercury in the Barometer, it is to be obſerved, that the cauſes ariſing from the circulations of the Atmoſphere and the fall of water out of it there alluded to, for the moſt part take place in the lower half of the Atmoſphere, or below the line of 3½ Engliſh miles of perpendicular height above the level of the ſea; now although we have reaſon to believe that the upper half above this line is far leſs diſturbed, and that motions in it are much leſs frequent than they are low down; yet it is poſſible that motions or currents may from circumſtances take place there, which may affect the general weight of the column, and accordingly produce alterations in the Barometer which cannot be accounted for from appearances.

Having now explained the comparative heights of the Barometer, with its fluctuations in the different places treated of, I ſhall conclude with making ſome obſervations concerning it as a weather glaſs; in which reſpect it is to be obſerved, that the Barometer is moſt uſeful in thoſe places where its fluctuations are greateſt; and this from the above deſcription, as well as from actual obſervations, appears to be upon the North of Europe; I ſhall therefore confine my obſervations to thoſe places, more particularly Great Britain, with perhaps occaſional remarks as to other places.

In the firſt place it is neceſſary to obſerve, that all calculations reſpecting the Barometer can have no regard to the denſity or elevation of the column of Atmoſphere, any farther than as they affect its weight; therefore it cannot indicate a change of weather cauſed by a change in either denſity or elevation, unleſs at the ſame time an alteration in weight takes place.

It is obvious to every one, that when the quantity of Atmoſphere in any particular place (from whatever cauſe) happens to be leſs than that ſurrounding it, that from its fluidity a motion will immediately commence from the other parts (more eſpecially from where the greateſt quantity is) toward where the deficiency is, in order to reſtore the equilibrium; this motion will begin firſt upon the borders of the deficiency, and from thence extend toward where the greateſt accumulation is; and by its beginning upon the borders of the deficiency, the current will be ſtrongeſt there. Now as the cauſe muſt take place before the effect, the Barometer, by indicating the deficiency of the medium quantity of Atmoſphere in any particular place, foretells the motion or current that will ruſh in to fill it up.—Thus the falling of the Barometer indicates wind, and as wind from a warmer climate, and from off the ſea, is always loaded with vapour, this vapour will be condenſed into clouds upon coming into a colder climate, or upon the land; and they again by their globules coaleſcing, will fall in rain; thus the Barometer indicates rain alſo, in ſo far as it neceſſarily follows wind; and thus rain, by rendering the Atmoſphere lighter, produces an additional fall in the Barometer, which laſt fall will be recovered when the ſhower is over, by the ſurrounding Atmoſphere flowing in to reſtore the equilibrium. Hence we ſee, that the winds between South and Weſt from their being the general courſe of the horizontal circulation, have the Barometer low, and the frequent rains attending them make it fluctuating.

When there is no conſiderable difference in temperature, and the air does not abound with vapour, the falling of the Barometer may indicate wind, without rain taking place; this frequently happens in the ſpring of the year, becauſe then the Atmoſphere is not ſo replete with vapour, with the ſame warmth of temperature, as it is in the fall of the year; but after a long tract of warm weather and drought, a very inconſiderable fall in the Barometer is often followed by a ſhower, becauſe the length of warm weather having loaded the air with vapour, a leſs degree in denſity will then the more readily let it fall. Indeed it is generally to be obſerved, that a conſiderable riſe or fall in the Barometer is more to be attended to in foretelling fair or foul weather, than the ſtate of elevation or depreſſion it immediately reſts at; only a riſe upon an elevation, and a fall upon a depreſſion, is more indicative of fair or foul weather than the contrary; alſo ſudden and great tranſitions in the Barometer always indicate the ſame in the weather, excepting when cauſed by ſudden and heavy falls of rain in warm weather.

As the Atmoſphere is moſt loaded with vapour toward the fall of the year, the increaſing cold of that ſeaſon is always condenſing it; for which reaſon we find, that in the latter end of ſummer, and during harveſt, a leſs fall of the Barometer is followed with rain, than in the ſpring; and from the greater quantity of vapour that is then floating, we find, that the North and N. E. winds, by condenſing it, are generally accompanied with rain, although by being in oppoſition to the general circulation, theſe winds commonly raiſe the Barometer.

It often happens in the winter ſeaſon, that the vicinity of cold (from reaſons already mentioned) will cauſe a fall in the Barometer, particularly if the cold is ſevere; for it may be obſerved, with warm and ſtill weather, particularly after warm weſterly winds, that when the Barometer falls very low, cold weather is not far diſtant; and that it commonly ſoon follows with bluſtering winds, upon which the Barometer immediately riſes again.

It hath already been obſerved, that whatever alteration takes place in the winds or weather, from a difference in denſity of the Atmoſphere, that it cannot be indicated by the Barometer, unleſs a difference in weight alſo take place. Thus winds from a froſty region toward a warmer, ſuch as the N. W. winds, which in the winter ſeaſon blow from off the eaſtern coaſts of N. America; and the N. E. winds which then blow from off the Weſt coaſts of Europe, from their being cauſed by a difference in denſity, cannot be indicated by the Barometer: indeed their continuance, by cauſing an accumulation, generally raiſes it, particularly the eaſterly winds from off the European coaſts, by its acting in oppoſition to the general circulation.

As to foretelling of rain, it is to be obſerved, that although the Barometer may be ſenſibly affected by a conſiderable fall of rain, yet the indication by it will precede the fall but a very little time, becauſe it can only begin to take place when the water in the ſhower quits the hold it has of the air; and therefore only precedes the ſhower the time between its beginning to deſcend, and its falling, which muſt be very inconſiderable. This indication of the fall of rain by the Barometer will be more viſible without where the ſhower falls, than in it, becauſe the preſſure of the deſcending Atmoſphere carried down by the ſhower continues the weight or preſſure upon the Barometer.—Hence in warm weather, when falls of rain are heavy and partial, the Barometer is often affected by diſtant falls, when no rain may fall immediately in the place where it is. This is particularly obſervable when thunder prevails, which by being affected by diſtant falls of rain, no doubt has given riſe to the idea of the falling of the Barometer foretelling thunder.

From all theſe circumſtances we may evidently ſee the cauſe of the Barometer being in many reſpects deficient, as a weather-glaſs; but the cauſe of its riſe and fall being fully known, future obſervations may in time be the means of laying down more certain and accurate rules concerning it.

THE END.

* * *

Speedily will be Publiſhed,

BY THE AUTHOR,

OBSERVATIONS,

SHEWING

THE CAUSE AND VARIOUS DIRECTIONS

OF THE

TIDES AND OTHER CURRENTS

IN THE

North Atlantic Ocean—upon its Shores—and in the Seas communicating with it.

[*Chalmers & Co. Printers, Aberdeen.*]

UC SOUTHERN REGIONAL LIBRARY FACILITY

A 000 026 753 4